Appendix A

GEOLOGY

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GEOLOGY

Purpose of Study and Scope of Work

The Bureau of Reclamation's (Reclamation) multidisciplinary evaluation of the sediment stored behind Savage Rapids Dam included a geologic investigation of the reservoir area upstream from the dam. This investigation builds upon earlier work completed in 1998 by ChemRisk, a service of McLaren/Hart, Inc., for Sportfish Heritage of Grants Pass, Oregon. Use of the McLaren/Hart data in this report is with the express written permission of Sportfish Heritage, within the specifications of their letter dated June 8, 1999. The purposes of Reclamation's geologic investigation conducted in 1999 were to:

- Develop a conceptual model of reservoir conditions and the depositional environment based on geologic mapping of the reservoir rim, underwater examination of reservoir bottom conditions, and interpretation of bathymetric surveys of the reservoir bottom
- Estimate the geometry and volume of the reservoir sediment through measurement of sediment thickness and interpretation of reservoir bathymetric surveys
- Determine the physical properties of the sediment particles, including particle size distribution, soil plasticity, and particle density, as determined from laboratory testing of field samples
- Verify the results of the McLaren/Hart (1998) investigation by screening selected field samples for contamination with heavy metals and other toxins

This appendix of the multidisciplinary report discusses, in detail, the first three of the above-listed study purposes and the work conducted to accomplish those goals. The results of screening for heavy metals and toxin contamination are deferred to the discussion of water quality issues appearing in Appendix C.

The geologic investigation was conducted in distinct phases, which were directly related to reservoir operations and the water surface elevation of the reservoir impounded behind Savage Rapids Dam. The initial phase consisted of reconnaissance-level geologic mapping of the entire reservoir area extending upstream from Savage Rapids Dam to the confluence of the Rogue River with Evans Creek, a primary tributary stream located just upstream from the upper end of the reservoir, near river mile (RM) 110.6. The geologic mapping conducted on May 18, 1999, was timed to coincide with low reservoir levels resulting from concurrent installation of stoplogs along the crest of the dam. Installation of the stoplogs necessitated opening the low-level radial gates of the dam. The geologic mapping was performed using both ground observation of exposures and a jet boat reconnaissance of the entire reservoir length.

Staff from the Sedimentation and River Hydraulics Group of Reclamation's Technical Service Center in Denver, Colorado, conducted bathymetric surveys of the reservoir bottom in early July 1999. The bathymetric data were compiled to develop a topographic map of much of the reservoir bottom from Savage Rapids Dam upstream to near the confluence with Evans Creek.

From September 20 through October 5, 1999, staff from the Geology, Exploration and Instrumentation Group of Reclamation's Pacific Northwest Regional Office in Boise, Idaho, conducted the main geologic investigation of the sediment stored behind Savage Rapids Dam. This work entailed drilling 12 holes from a floating drilling platform located in the reservoir upstream from the dam. The total drilling footage completed in this investigation was 396.6 feet. Laboratory tests were performed on 25 field samples to determine standard properties of the reservoir sediments and on 4 samples to screen for heavy metals content.

The field investigations and the results of the study are presented in the following sections of this appendix.

Location

Savage Rapids Dam is located approximately at RM 107.3 on the Rogue River at the Jackson and Josephine County line in southwestern Oregon, about 5 miles east of Grants Pass (Water and Power Resources Service, 1981). The dam is located in the SE ¼ of the SE ¼ of Section 24, Township 36 South, Range 5 West. Savage Rapids Dam is a combination gravity and multiple arch concrete dam with a crest length of 464 feet and a structural height of 39 feet (Reclamation, 1997). The hydraulic height of the dam (height of the structure from the original channel bed elevation to the crest of the dam) is 30 feet. The crest elevation of the dam is 957.6 feet in the 1988 North American Vertical Datum (NAVD) but 953.0 feet in the 1929 National Geodetic Vertical Datum (NGVD). The spillway crest is fitted with 16 stoplog bays which raise the crest 11 feet, to elevation 968.6 feet (964.0 feet in the 1929 NGVD), for irrigation deliveries. The stoplog bays are numbered sequentially from right to left beginning at the pumping plant, located on the right end of the dam (Russell, 1950). The river outlet for the dam consists of two 7-by-16-foot radial gates, with a total capacity of 6,000 cubic feet per second. Fish ladders are present on both ends of the structure, with the north ladder located on the right abutment of the dam and the south ladder located on the left, adjacent to the headworks for the Gravity Canal.

The permanent pool impounded behind the dam extends about 3,000 feet upstream from the dam to a point just upstream from the boat launch at Savage Rapids Park, located on the left rim of the reservoir. The water surface elevation of the reservoir is raised about 11 feet during the irrigation season by the installation of stoplogs across the crest of the dam. This rise in the reservoir water surface extends the reservoir about 15,000 feet upstream to approximately RM 110.6 for the duration of the irrigation season, which

typically extends from about mid-May to about mid-October each year. The stoplogs are removed at the end of the irrigation season, and the section of the reservoir upstream from Savage Rapids Park returns to free-flowing river conditions from the late fall to early spring.

Surveys and Base Map

The geologic investigation of the sediment stored behind Savage Rapids Dam entailed the integration of newly collected field data with the results obtained from previous work at the site. The previous work was conducted using several different survey datums, and compilation of these various data bases into one consistent datum was needed before analysis of the sediment type and volume could be undertaken. A key element in this compilation was to use the same survey datum as that used in the hydraulics and sediment transport analyses (see Appendix B).

The following sections describe the field surveys performed in the 1999 sedimentation study and the processes used to convert previous work to the datums used for this report. The last section describes the process used to generate the base map and special considerations used to fill in gaps in the data and the adjustments made to fit data collected in earlier studies.

1999 Field and Bathymetric Surveys

The 1999 Reclamation field surveys were collected using the 1983 North American Datum (NAD), Oregon South Zone state plane horizontal grid. Vertical positions were obtained using the NAVD of 1988. The bulk of the survey work was performed for the hydraulic and sediment transport studies. The work included bathymetric surveys of the reservoir and portions of the Rogue River downstream from the dam (from Pierce Riffle to the confluence with the Applegate River) and land surveys to tie into existing survey control points and various features of Savage Rapids Dam. These surveys are described in greater detail in the discussion of stream hydraulics and sediment transport (see Appendix B). The following discussion addresses the application of the survey data to the geologic analyses of the sediment character and volume.

Reclamation staff conducted the bathymetric surveys using a cataraft equipped with a small out-board motor, a Raytheon sonar depth sounder, and a survey-grade Trimble global positioning system (GPS) receiver set up with a radio link to the boat to record the position of each depth sounding. Note that the bathymetric survey did not extend into the forebay area immediately upstream from the dam because flows in the Rogue River were being passed through bays 1 through 4 on the right end of the dam at the time of the survey in early July 1999. The resulting current made it unsafe to enter the forebay with the cataraft. Staff from the Sedimentation and River Hydraulics Group of

Reclamation's Technical Service Center in Denver, Colorado, compiled the depth soundings and prepared a bathymetric map of the reservoir bottom at a scale of 1 inch equals 100 feet and a contour interval of 2 feet. This map was then used to interpret reservoir conditions on the basis of the bottom morphology and to select locations for subsequent drilling and sampling of the reservoir sediments. The bathymetric map has been used as the base map for the geologic investigation (see drawing 448-100-17 in attachment A), as is discussed in the following section. This base map was used to prepare a series of geologic cross sections through the reservoir area for calculation of the volume of the sediment stored behind Savage Rapids Dam.

Upon completion of the drilling program, Ms. Roberta Robles of the Rogue Valley Council of Governments in Central Point, Oregon, performed additional surveying to obtain final locations for the drill holes. Ms. Robles used a Trimble survey-grade GPS receiver. This survey also used the 1983 NAD and the 1988 NAVD to maintain consistency with the earlier work conducted for the hydraulic and sediment transport analyses. Note that three drill holes (AP-99-1, -3, and -12) were not surveyed. The marker buoys placed after completion of holes AP-99-1 and 99-3 were stolen or displaced by vandals prior to the survey. Hole AP-99-12 was drilled over the weekend, following completion of the survey. Field locations for these holes were taken using a recreational-grade Garmin 12 GPS receiver, but these locations have not been used on the base map because the GPS locations have too large an error. The locations shown on the map are based on triangulated field positions using landmarks along the shoreline, but they are more accurately located than were the Garman 12 GPS locations. The locations of these three holes appearing on the respective geologic logs in attachment B have been measured from the plotted locations on the base map.

Conversion of Earlier Work to 1999 Survey Datums

Use of the 1983 NAD and the 1988 NAVD provided consistency between the geologic and hydraulic portions of the 1999 sedimentation study but required conversion of all previous work at the dam to the more recent datums. The processes used to convert the older data to the current survey datums are discussed in the following sections.

The as-built plan of Savage Rapids Dam (drawing 712-D-9) is based on the original 1922 plan of the dam (file drawing 256C or Reclamation drawing 712-100-58) and has no reference to a horizontal coordinate system. Vertical positioning of the dam is tied to the 1929 NGVD, based on a U.S. Geological Survey (USGS) monument (brass cap NGS J257, 1954) on the left end of the dam. The elevation shown on the brass cap (elevation 968 feet) agrees closely with the crest elevation of the dam shown on drawing 712-D-9 (elevation 968.0 feet). Note that the reservoir water surface gauge on the pumping plant on the right end of the dam also is tied to the 1929 NGVD.

The plan of the dam was converted to the 1983 NAD/1988 NAVD using land surveys conducted at the dam as part of the bathymetric survey of the reservoir. The land survey

tied in brass cap NGS J257 to the 1983 NAD datum and obtained positions for several prominent features of the dam, including the corners of the right abutment pumping plant. These points were used to position the plan of the dam on the base map within the 1983 NAD horizontal grid (Oregon South Zone). Conversion of the 1929 NGVD to the more recent 1988 NAVD was accomplished by surveying several locations along the crest of the structure, including the brass cap, and comparing them to the older elevations. This comparison showed that the 1988 NAVD was 4.6 feet higher than the 1929 NGVD, and a conversion factor of plus 4.6 feet was added to all elevations derived from the 1929 datum, including reservoir elevations measured at the right abutment staff gauge during the drilling program.

The conversion of the hole locations from the McLaren/Hart (1998) investigation to the 1983 NAD/1988 NAVD involved a more detailed process. A private surveying contractor, Max H. Hull Surveying, of Grants Pass, Oregon, located these holes for Sportfish Heritage, Inc., and the survey data is used in this report with the express permission of Sportfish Heritage. Vertical control in that survey was based on a local coordinate grid system using U.S. Coastal and Geodetic Survey brass cap 968 J 2571934 (elevation 968.785 feet), located near the left end of the dam (Max H. Hull Surveying, personal communication). Two parallel processes were used to convert these hole locations to the 1983 NAD and 1988 NAVD for inclusion on the base map. A graphical analysis was performed in which the outline of the dam and hole locations were digitized from figure 2-1 of the McLaren/Hart report (1998) and then overlaid onto the same outline on drawing 448-100-17 (the base map) in attachment A. This process worked well, except for holes SB-4 and -5, which had been truncated off the right margin of figure 2-1 in the Pacific Northwest region file copy of the McLaren/Hart report. While this graphical analysis achieved a suitable best fit for horizontal locations of the drill holes, spatial control of vertical elevations for the drill holes could not be obtained through this process.

Max H. Hull Surveying used a local grid based on a brass cap monument located on the left end of the dam to survey the 1998 McLaren/Hart drill holes. Vertical elevations reported for the holes are based on the elevation for the brass cap, which appears to be in the 1929 NGVD. Horizontal coordinates were converted to the 1983 NAD by plotting the surveyed locations of the drill holes, brass cap, and points taken on the dam onto the base map prepared for this study (drawing 448-100-17). The 1998 surveyed hole locations were then compared to the digitized locations appearing in the McLaren/Hart report and adjusted to a best fit. The surveyed locations provided by Max H. Hull Surveying were used to plot the McLaren/Hart drill holes on drawing 448-100-17 in all instances where survey date were available.

Surveyed locations were not reported for drill holes NB-15 and -16, and the locations shown on the base map are those obtained from the graphical analysis of the location map in the 1998 McLaren/Hart report. Because vertical elevations are also not available for holes NB-15 and -16, the top of each hole was arbitrarily fitted to match the reservoir bottom elevation appearing in the 1999 bathymetric surveys. Note that the surveyed

elevations of the 1998 McLaren/Hart drill holes do not coincide with the reservoir bottom surface, as determined from Reclamation's 1999 bathymetric surveys, and are typically 2 to 3 feet higher than the corresponding bathymetric data. This discrepancy in elevation may result from a datum error in conversion of the local survey, which is assumed to be the 1929 NGVD system, to the 1988 NAVD elevations. A comparison of the elevations for the brass caps used in both the 1998 and 1999 field surveys shows a vertical difference of 0.785 foot, which would not account for all of the 2- to 3-foot discrepancies noted between the 1998 elevations and the 1999 bathymetry. Possible discrepancies in elevation cannot be further resolved without additional field work to locate all brass cap survey monuments, verify their identification, and resurvey their locations. This work could be conducted as part of final design data collection efforts, if deemed necessary.

Lacking any positive indication of a significant survey datum bust, the drill holes have been plotted at their surveyed collar elevations on the geologic sections prepared for this study. Alternately, this difference in elevation may be related to scouring of the reservoir bottom during large floods experienced during the 1998-99 winter season. The sediment within the reservoir rises to nearly the top of the concrete portion of the dam, particularly on the right side, and significant scouring of the upstream bar deposit could have occurred during large flood events.

Compilation of Bathymetric Base Map

The base map developed for this study is a compilation of data from a number of different sources. The outline of the dam and appurtenant structures has been digitized from Reclamation drawings 1313-D-1 and -2, which are based on 1972 surveys at the dam. The outline of the dam was fitted to the 1983 NAD Oregon South Zone state plane coordinate system using the physical features of the dam, as discussed in the previous section. Contours of the reservoir bottom have been developed from Reclamation's 1999 bathymetric survey. The base map has been prepared with a contour interval of 2 feet and has a scale of 1 inch equals 100 feet. The base map includes the locations of all holes drilled by both McLaren/Hart, Inc., in 1998, and by Reclamation in 1999, using the processes described in the previous section.

Bathymetric data were not collected in the forebay immediately upstream from the dam because of safety considerations. The four stoplog bays were open on the extreme right end of the dam at the time of the 1999 survey, and this resulted in strong currents. Where available, older contours (1972), shown on drawings 1313-D-1 and -2, have been digitized for the forebay area. These contours are spaced on an approximate interval of 5 feet. A conversion to the 1988 NAVD was required to complete the forebay portion of the contour map because the 1972 contours were surveyed in the 1929 NGVD. The conversion factor of 4.6 feet, determined from 1999 field surveys of the dam (see previous section), was rounded to 5 feet to simplify the process of converting the 1972 contours to the newer datum. The converted 1972 contours have been highlighted

using a dashed line on the base map to distinguish them from the newer contours based on the 1999 bathymetric data, which are shown with a solid contour line.

Geologic Investigations

This section summarizes previous geologic investigations and related work conducted at Savage Rapids Dam. Copies of all referenced reports are maintained in the technical files of the Geology, Exploration and Instrumentation Group in Boise, Idaho. Also described in this section are the investigation strategy, field methodology, and laboratory testing procedures used in the current Reclamation investigation of the reservoir sediments stored behind the structure.

Previous Investigations

1950 Reclamation Investigation.—Reclamation undertook a geologic reconnaissance of Savage Rapids Dam in 1950 in preparation for rehabilitation and betterment of the structure that was subsequently completed between 1953 and 1955 (Reclamation, 1997). The reconnaissance included geologic mapping of the exposed foundation of the dam and its abutments. Note that exploratory drilling of test holes was not conducted as part of this study. A geologic map and cross section were developed from field mapping and from construction drawings and field notes of the dam dating from original con-struction in 1921 and 1922. The original drawings and notes were found in the files of the Grants Pass Irrigation District (GPID). The results of the reconnaissance are presented in a geologic report by Russell (1950). Subsequently, the construction drawings have been microfilmed by Reclamation.

1981 Reclamation Safety Evaluation of Existing Dams Examination.—An engineering geological evaluation of Savage Rapids Dam was conducted in 1981 as part of Reclamation's Safety Evaluation of Existing Dams (SEED) program. A certified engineering geologist (D.H. Jepsen), retained by Goodson and Associates, Inc., under contract to Reclamation, performed this evaluation. This evaluation addressed foundation conditions and performance based on an onsite examination and a review of existing documentation, including Russell's earlier report (1950). The evaluation also examined local seismicity and reservoir rim stability for Savage Rapids Dam. Based on information available at the time of the evaluation, there were no dam safety deficiencies identified for the foundation other than an operations and maintenance issue concerning continued scouring of the cemented gravel downstream from the spillway apron on the right end of the dam. The review of reservoir rim stability did not document the presence of any landslides upstream from Savage Rapids Dam. An engineering geological report by Goodson and Associates (1981) presented the findings of the evaluation.

1992 Reclamation Reservoir Survey.—Reclamation performed a reservoir sedimentation study of the Rogue River upstream from Savage Rapids Dam in 1992. This study consisted of the survey of 17 unmonumented cross sections between the dam and RM 110, under full reservoir conditions, and the collection of 5 surface sediment samples obtained from the exposed shoreline between Savage Rapids Dam and Savage Creek.

Because no pre-dam topography exists for the reservoir, the pre-dam thalweg of the river was estimated using the base elevation of the dam. The elevation is as shown on construction drawings and on 1923 USGS topography and river profiles located upstream from the reservoir area. Pre-dam cross sections were then extrapolated from the estimated thalweg and compared to the measured 1992 cross sections to arrive at an estimate of the sediment stored behind Savage Rapids Dam. A volume of 320 acre-feet (i.e., 516,267 cubic yards [yd^3]) of stored sediment was calculated, assuming full reservoir pool conditions behind the dam. A memorandum report documenting the reservoir surveys and sediment volume calculations was completed in 1992 (Blanton, June 12, 1992).

GPID staff collected the surface sediment samples from the exposed shoreline along the reservoir prior to stoplog installation and filling of the reservoir in April 1992. The samples were transferred to the Reclamation office in Denver, Colorado, and tested for standard properties, including gradation, and screened for trace elements. Trace elements were within baseline ranges for the elements tested. The results of the laboratory testing are discussed in a second memorandum report (Blanton, November 20, 1992).

1998 McLaren/Hart, Inc., Investigation.—ChemRisk, a service of McLaren/Hart, Inc., under contract to Sportfish Heritage of Grants Pass, Oregon, undertook additional investigation of the reservoir area upstream from Savage Rapids Dam in 1998. This investigation entailed drilling 13 sample holes along the exposed surface of an extensive bar deposit along the north bank (i.e., right bank when looking in the downstream direction) of the reservoir and 5 additional holes along a finer-grained sediment bar on the south bank. Laboratory testing was performed on 50 field samples and included testing for both standard engineering properties and over 40 chemical analytes, including pesticides and heavy metal contaminants. While elevated levels were measured for some of the analytes, none of the detected levels was high enough to trigger a more detailed Tier II contaminant evaluation, as established by the *Dredged Material Evaluation Framework* (U.S. Army Corps of Engineers [Corps] et al., 1998).

The McLaren/Hart report (1998) also reviewed the earlier reservoir sediment volume estimated by Reclamation (Blanton, June 12, 1992) and recalculated the volume based on the additional data obtained from their exploratory drilling. These data were then extrapolated further upstream from the test drilling to include the same full-pool reservoir area as that used in the original Reclamation estimate (i.e., through reservoir

cross section 17 near RM 110). The McLaren/Hart sediment analysis derived a range of volume estimates varying from over 600,000 to as much as 1,000,000 yd^3.

Current Investigation

The current Reclamation investigation of the reservoir sediments impounded behind Savage Rapids Dam built upon the previous work by McLaren/Hart, Inc. (1998), by expanding exploration of the sediments to the permanently submerged portion of the reservoir through use of a floating drilling platform. In addition to further defining the geometry of the north bank sediment bar in the central part of the reservoir, most of the drill holes extended sampling upstream through the permanent reservoir pool impounded by the concrete crest of the dam. This permanent reservoir pool extends about 3,000 feet upstream from the dam above the mouth of Savage Creek at Savage Rapids Park. Geologic mapping, drilling, testing, and sampling collection conducted for this investigation were performed by staff from the Geology, Exploration and Instrumentation Group of Reclamation's Pacific Northwest Regional Office, Boise, Idaho.

Geologic Mapping.—Reconnaissance-level geologic mapping was conducted for the reservoir area extending upstream from Savage Rapids Dam to the confluence of the Rogue River with Evans Creek, a primary tributary stream located just upstream from the upper end of the reservoir, near RM 110.7. The geologic mapping was conducted on May 18, 1999, and was timed to coincide with low reservoir levels resulting from concurrent installation of stoplogs along the crest of the dam, which necessitated opening of the low-level radial gates at the dam. The geologic mapping for the entire reservoir length was conducted using a locally procured jet boat from Hellgate Excursions, Inc., of Grants Pass, Oregon. Additional mapping included ground observation of exposures adjacent to and immediately upstream from the dam, which was accomplished following completion of the jet boat reconnaissance.

A suitable base map for the reservoir could not be located, other than the Rogue River, Oregon, 7.5-minute provisional quadrangle map published by USGS. Color, laminated photocopies were made from 1996 aerial photographs of the reservoir area obtained from the United States Bureau of Land Management office in Medford, Oregon, and used as a base for the reconnaissance mapping. The results of the reconnaissance-level mapping appear on the geologic map of the reservoir, figure 1. (See "Site Geology," below.)

Drilling and Sampling Methods.—

Drilling Equipment.—Exploratory drilling was conducted using an Ingersoll-Rand A200 skid-mounted drill, operating from a custom-built drilling platform floating on pontoons. The assembled platform measured approximately 21 feet wide by 20 feet

long by 3.5 feet high. The platform included an 8-by-10-foot deck extension which projected out from the midpoint of the platform and functioned as a work area for the drill crew to stack drill rods and accessory tools. An outboard motor was used to propel the platform. The drill rig and platform were hauled to the site in sections on transport trucks and assembled at Savage Rapids Park with the aid of an overhead crane provided by R.A. Cook Crane Service of Grants Pass, Oregon. When fully loaded, the drilling platform weighed about 21,000 pounds and drafted about 30 to 36 inches of water. Photograph 1 shows the drilling platform in operation at Savage Rapids Dam.

Drilling and sampling of the reservoir sediments was conducted using nominal10-inch outside diameter (6.25-inch insider diameter) hollow-stem flight augers. Flight augers were selected as the primary drilling technique to minimize disturbance of the lake bottom. Their use resulted in minimal induced turbidity of the reservoir water. Rotary drilling techniques were available as a backup procedure at Savage Rapids Reservoir in the event that drilling with hollow-stem flight augers proved unsuccessful.

Photograph 1.—Savage Rapids Dam, Rogue River Basin Project, Oregon. View downstream showing Reclamation's custom built, floating drilling platform in operation on drill hole AP-99-10. Drilling equipment consists of a skid-mounted Ingersoll-Rand T200 rotary drill, which was used to advance 10-inch outside diameter, hollow-stem flight augers to a bottom depth of 27.8 feet below the lake surface in this hole. The spillway and pumping plant portions of Savage Rapids Dam are present in the background of this photograph. (Reclamation photograph by Richard Link; September 30, 1999.)

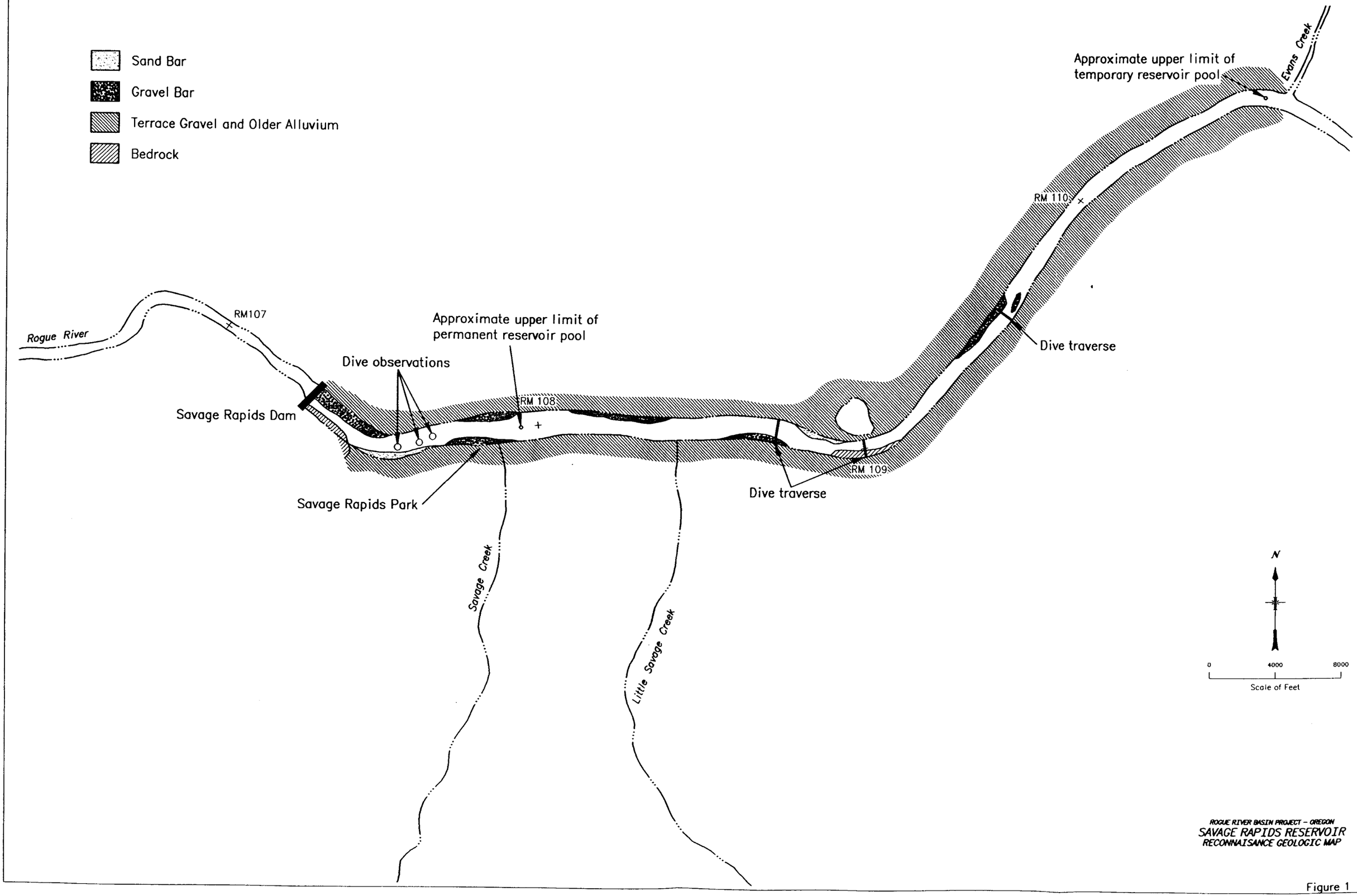
Sand Bar
Gravel Bar
Terrace Gravel and Older Alluvium
Bedrock
Rogue River
RM107
Savage Rapids Dam
Dive observations
Approximate upper limit of permanent reservoir pool
RM 108
Savage Rapids Park
Savage Creek
Little Savage Creek
RM 109
Dive traverse
RM 110
Approximate upper limit of temporary reservoir pool
Evans Creek
N
0
4000
8000
Scale of Feet
ROGUE RIVER BASIN PROJECT - OREGON
SAVAGE RAPIDS RESERVOIR
RECONNAISANCE GEOLOGIC MAP

Figure 1

There was concern that the large gravel and cobble material known to exist in the gravel bar on the right abutment of the dam and in the upstream reservoir might prevent advancement of the drill tools or the collection of field samples. Drilling with the hollow-stem flight augers was successful, and the backup rotary drilling tools were never employed in the field investigation.

Testing and Sampling.—Drive samples were collected using split-tube barrels measuring 2.75, 3, and 3.5 inches in diameter and 2 feet long, mounted on Nw Mobilok drill rods. Samples were collected by driving the spilt-tube barrel into the lake bottom with a 350-pound safety hammer dropped a vertical distance of about 30 inches. The hammer was raised using a cathead and manila rope. The sample interval typically varied from 1.5 to 2.0 feet, depending on the resistance of the sediment being sampled. Field notes maintained during sampling included the number of hammer blows delivered through the sample interval and any irregularities noted during testing, such as settlement of the drill string under the weight of the hammer and excess slough in the sample tube. Sample recovery was poor in the first two drill holes (AP-99-1 and -2), and a number of methods were experimented with until a suitable technique was developed to obtain adequate sample recovery. The most satisfactory method employed a 3-inch inside diameter split-tube fitted with a basket catcher with very closely spaced fingers. The sample barrel interior was sprayed with PAM aerosol vegetable cooking coating, and a baffle of plastic wrap was installed behind the basket catcher. In addition, the sampler was allowed to rest at the bottom of each sample interval for a minimum of 10 to 15 minutes to improve adhesion of the sample to the inside of the sample tube before the sample was retrieved from the bottom of the hole. This last measure proved to be the most effective in improving sample recovery.

Field samples were logged in the field and classified as to soil type using the Unified Soil Classification System (USCS), as defined in *Designation USBR 5005-86, Procedure for Determining Unified Soil Classification - Visual Method* (Reclamation, 1990). Select samples were also photographed in the field to further document physical properties of the reservoir sediment, including particle size distribution, stratification, and other internal structures. Samples were labeled in the field and stored in ziploc freezer bags for subsequent laboratory testing.

Contaminant Sampling and Procedures.—Reclamation's investigation of the reservoir sediments impounded behind Savage Rapids Dam included contaminant screening of select field samples to verify the earlier results obtained by McLaren/Hart (1998) and to extend testing into the upstream portions of the reservoir that were not included in the previous work. Contaminant sampling required special sampling equipment and handling procedures to obtain valid samples and laboratory test results. The special equipment and procedures are discussed in the following paragraphs, along with modifications to the methodology made onsite during field sampling.

Contaminant sampling was conducted near the end of the field investigation after the bulk of the conventional sampling for standard engineering properties had been completed.

Contaminant sampling was initially conducted using a 2.75-inch id split-tube, stainless steel barrel measuring 2.0 feet long. Initial sampling at Savage Rapids using conventional sampling equipment had demonstrated that samples could not be recovered without the use of a basket catcher and a plastic-wrap baffle placed behind the catcher. Use of flapper valves had been attempted but proved totally ineffective. A teflon-coated basket was installed in the stainless steel barrel for contaminant sampling. A gallon of de-ionized water mixed with about 1.25 fluid ounces of Liqui-Nox detergent was used to decontaminate the stainless steel barrel for each sample interval. The barrel was then rinsed in a spray of de-ionized water. The de-ionized water was obtained from the Reclamation water quality laboratory in Boise, Idaho. A complete record of barrel decontamination and contaminant sample handling was maintained onsite during the field investigation, and the log book has been placed in the technical files of the Geology, Exploration and Instrumentation Group in Boise, Idaho.

Repeated attempts to sample with the stainless steel barrel failed to recover any reservoir sediment, and it became evident that the fingers of the teflon-coated basket catcher were too widely spaced to retain the sample inside the barrel. After consultation with the technical staff at Reclamation's Technical Service Center in Denver, Colorado, it was decided to conduct the contaminant sampling with the same equipment that had already proven successful in the collection of the conventional samples. Decontamination procedures were identical to those described above. This change in methodology entailed the use of a nonstainless steel sample barrel and an uncoated steel basket catcher. A sample of the wash water was retained for testing to evaluate potential background contaminant levels of the nonstainless steel barrel and basket.

Even with the change to the conventional sampling equipment, generally poor recovery continued in the contaminant sample intervals. As a final measure to improve recovery to acceptable levels, the interior of the barrel was sprayed with PAM aerosol vegetable cooking coating. This coating proved to be very effective in improving sample recovery and should not have adversely affected the results of the laboratory contaminant testing.

Conventional sampling in the reservoir behind Savage Rapids Dam established the presence of a large pothole in the river bottom, about 1,800 feet upstream from the dam, which had been infilled with reservoir sediment. Drilling demonstrated that the pothole extended at least 10 feet below the base elevation of the dam, suggesting that the pothole would have acted as a trap for any contaminants migrating downriver from upstream mining districts. The bulk of the contaminant sampling was concentrated in this area in drill hole AP-99-12, although one sample taken at the upstream end of the permanent reservoir pool at Savage Rapids Park was also collected for testing. Due to the thickness of sediment present in the pothole, contaminant sampling was alternated with conventional sampling to expedite drilling. The pre-dam river bed was encountered

in a conventional sampling interval with a sample barrel that had not been decontaminated. However, as this sample represented the material directly on the old river bed and had the highest likelihood of containing contaminants, the sample was submitted to the lab with appropriate notes about the history and condition of the sample and its test equipment.

All contaminant samples were stored in sterilized samples jars and placed on ice until shipping to Reclamation's laboratory at the Technical Service Center in Denver, Colorado. The samples were shipped with appropriate chain-of-custody documentation and field notes on decontamination and sampling procedures. The results of the laboratory testing are discussed in Appendix C.

Hole Abandonment.—All the holes drilled in Savage Rapids Reservoir were decommissioned and abandoned upon completion, without installation of instrumentation. Reverse circulation of the auger string was used to backfill all holes with cuttings removed during drilling operations. This hole abandonment procedure was in accordance with the directions of the Oregon Division of State Lands, as expressed during the process of obtaining Reclamation's remove-and-fill permit. The permit was obtained as part of the National Environmental Policy Act compliance for the field investigation.

Laboratory Testing.—Field samples were evaluated on the basis of percent recovery and mass of retained material in the sample tube. Then, 25 samples were submitted for laboratory testing to determine standard physical and engineering properties. Included in the laboratory testing program were (1) particle size distribution, including hydrometer for the minus No. 200 sieve fraction; (2) soil plasticity, or Atterberg limits; (3) fall diameter of sand-size and finer material; and (4) specific gravity of the minus No. 4 fraction. Initial testing of the sediment samples showed extremely low concentrations of the silt and clay fractions, and the requirement for the hydrometer, Atterberg limits, and fall diameter were canceled because sample mass was insufficient to perform these tests. The laboratory testing was performed under contract with Materials Testing and Inspection, Inc., a private, certified testing laboratory in Boise, Idaho. All test procedures conformed to Reclamation standard laboratory test designations, as described in *The Earth Manual, Part 2* (Reclamation, 1990). At the recommendation of Mr. Mark Siipola of the Corps in Portland, Oregon, the test procedure for particle size distribution was modified to include the addition of the No. 230 sieve (i.e., 0.063-millimeter [mm] particle diameter). This diameter corresponds to the demarcation between very fine sand and silt, and high concentrations of material passing the No. 230 sieve have been shown to be detrimental to fish. The concentrations passing the No. 230 sieve are shown in the center columns of the respective geologic logs of the 12 holes drilled for this investigation.

Laboratory soil classifications were developed for each sample interval using the USCS, as defined in *Designation USBR 5000-86, Procedure for Determining Unified Soil Classification - Laboratory Method* (Reclamation, 1990). Geologic logs have been prepared for each drill hole and include both the visual and laboratory soil classifications for
the samples. These logs appear in attachment B of this appendix. The results of the laboratory tests are also reported on the gradation test plots appearing in attachment C of this appendix. All samples have been retained for future reference at the Pacific Northwest Regional Office in Boise, Idaho.

Site Geology

The following discussion of the site geology for Savage Rapids Dam and Reservoir is based on published geologic mapping of the area, supplemented by site-specific observations reported in various Reclamation documents for the dam. Published geologic mapping specific to the dam and reservoir is not available, although both areas are included on the geologic maps of central Jackson (Beaulieu and Hughes, 1977) and Josephine (Ramp and Petersen, 1979) Counties and on larger-scale maps by the USGS (Smith and others, 1982). These maps form the primary references for the site geology at Savage Rapids Dam. Site-specific observations reported by Russell (1950) and Goodson and Associates (1981) discuss the immediate vicinity of the dam, while field observations of the reservoir area were made specifically for this study. The McLaren/ Hart report (1998) also discusses the reservoir geology immediately upstream from the dam.

Bedrock Units

The foundation bedrock of Savage Rapids Dam and its reservoir consists of variably metamorphosed volcanic and sedimentary rocks of the Applegate Group, which is generally accepted to range from Paleozoic to Triassic in age (Beaulieu and Hughes, 1977; Ramp and Petersen, 1979; Smith et al., 1982). Geologic mapping of the unit has identified two distinct rock sequences within the Applegate: (1) a dominantly volcanic sequence of altered lava, pillow lava, flow breccia, pyroclastics, and tuff with minor sedimentary interbeds and (2) an altered sequence of predominantly sedimentary rocks, including tuffaceous argillite, chert, siltstone, sandstone, conglomerate, and limestone with minor interbeds of volcanics. Deposition of the Applegate occurred under marine and volcanic island arc conditions adjacent to the continental margin. The age of the Applegate has been established as Early Permian to Late Triassic on the basis of fossils recovered from the metasedimentary sequence (Ramp and Petersen, 1979).

Thrust faults have been mapped in the Applegate Group, and these thrusts are repeatedly truncated by high-angle faults. Both the volcanic and sedimentary sequences have been variably metamorphosed, probably in conjunction with the intrusion of igneous plutons and associated dikes into the formation. Several plutons composed of diorite have been mapped in the area, including one in the nearby Evans Creek drainage, at the upper end

of the reservoir, and one very large pluton, down-stream, near the town of Grants Pass. Heavily mineralized zones occur in association with the plutons and dikes, and much of the early history of the Rogue River Valley involved extraction of ores from these deposits. Lava flows are commonly altered to greenstone and greenschist (Smith and others, 1982), while the metasedimentary sequence includes argillite, shale, schist, and marble. Donati and others (1996) studied the Applegate Group farther to the south, near the California border, and have established the timing of the deformation and metamorphism as the Middle Jurassic, around 173 Ma, based on radiometric dates.

Metavolcanic Rocks (TrPzmv).—Outcrops of metavolcanic rocks of the Applegate Group are exposed on the left abutment of Savage Rapids Dam, extending about 1,100 feet upstream and 300 feet downstream from the structure. Most of the south ladder is also founded on the metavolcanics, as are the headworks for the Gravity Canal on the south end of the dam. Russell (1950) demonstrated that the metavolcanics extend northward out into the river channel beneath the dam to the south end of spillway bay 5 (the numbering of the bays begins with bay 1 on the north end of the dam and progresses to bay 16 on the south end). Russell based his description on his geologic mapping at the dam site and a review of construction records on file at the office of the GPID. Construction of the low-level radial gate outlets in spillway bays 10 and 11 required rock excavation through the metavolcanics to approximate elevation 938.6 (i.e., elevation 934.0 in the 1929 NGVD). Bedrock outcrops were visible on the right abutment of spillway bay 10 when the low-level outlet was opened for stoplog installation in May 1999. Mapping of reservoir geology and site conditions in 1999 located hard outcrops of metavolcanics along the south bank of the Rogue River at RM 109.0, at the Have A Nice Day R.V. Park and campground, as shown in photo-graph 2. Subsequent examination of the area by Reclamation divers confirmed submerged outcrops of the metavolcanics extending about 50 feet out into the river from the south bank (see attachment D for the dive team report). The manager of the R.V. park indicated that the outcrops exposed along the riverbank had appeared after heavy scouring of the area during the November 1998 flood. This flood had inundated the R.V. park and nearly overtopped State Highway 99 at that location.

Russell (1950) describes the foundation rock as dark gray-green diabase dikes and greenstone, with bands of serpentine. He noted that the diabase and greenstone were hard and resistant to erosion, while the serpentine was softer and suffered from "etching out." Subsequent review of the site by Goodson and Associates (1981) showed that the bulk of the metavolcanics consisted of greenstone with a generally fine-grained groundmass with neither prominent crystals nor inclusions. Thin dikes and stringers of quartz were noted in the metavolcanics on the left abutment, upstream from the dam, during the 1999 Reclamation investigation.

Outcrops of the metavolcanics are generally hard (H3), requiring a heavy hammer blow to break off corners of the exposures (Reclamation, 1998). The degree of weathering was

*Photograph 2.—**Savage Rapids Dam, Rogue River Basin Project, Oregon**. View upstream showing metavolcanic bedrock outcrops of the Applegate Group exposed along the south shoreline of Savage Rapids Reservoir at the Have A Nice Day RV Park and campground near RM 109.0. These outcrops were exposed by scouring during flooding which occurred in November 1998 and project about 50 feet out into the reservoir from the left bank, as documented in a later underwater traverse performed at this site by divers from the Pacific Northwest Region Dive Team. (Reclamation photograph by Richard Link; May 18, 1999.)*

difficult to evaluate on the basis of surface exposures and the fine-grained groundmass. The condition of the rock was logged as slightly weathered (W3) where corners of outcrops were broken off with a rock hammer. Oxidation was generally limited to the surface of the exposure, and the hammer rang when striking heavy blows to the outcrop. Weathering probably extends into the moderately weathered range where more intensely metamorphosed materials are present in the foundation. The metavolcanics are slightly to very slightly fractured (FD2), with fracture surfaces typically spaced from about 1 to 4 feet apart. Fractures commonly occurred in two prominent joint sets that are near vertical and subhorizontal, imparting a very blocky appearance to the outcrops.

Prominent bedrock shelves or benches were observed forming along subhorizontal fracture surfaces at several locations on the left abutment, upstream from the dam. Localized zones of intense to very intense fracturing were noted at scattered locations on the abutment.

Metasedimentary Rocks (TrPzms).—During the course of the 1999 Reclamation field investigation, outcrops of metasedimentary rocks of the Applegate Group were observed within the reservoir area upstream from Savage Rapids Dam. While retrieving drilling equipment at the site of hole AP-99-1, the Reclamation dive team reported a submerged outcrop of metaconglomerate on the reservoir bottom. This site is about 1,300 feet upstream from the dam, near RM 107.60. (See drawing 448-100-17 for location.) The dive report describes the outcrop as "a bold exposure of in situ conglomerate." (See attachment D for the dive team report.) Additional outcrops of the metasedimentary rocks probably occur in the reservoir upstream from RM 109.0, where the Rogue River intercepts the trend of a prominent band of metasediments mapped by Beaulieu and Hughes (1977) and by Smith and others (1982). If outcrops are present in this area, they are submerged and have not been noted in spot observations by the divers.

Surficial Materials

Surficial deposits at Savage Rapids Dam and upstream along the reservoir consist of several distinct units of alluvium that are Quaternary in age. The alluvium is dominated by older terraces that flank both sides of the reservoir and underlie the north end of the dam. Younger alluvium within the channel of the Rogue River is largely submerged by the reservoir impounded by Savage Rapids Dam. Included in the surficial deposits are the reservoir sediments that have accumulated behind the dam since completion of construction in 1922. Each of these alluvial units is described in the following paragraphs.

Terrace Gravels and Older Alluvium (Qtg).—Prominent terraces of older river channel alluvium (Qtg) flank both sides of the Rogue River within the reservoir area and form the right abutment of the dam. Mapping by Beaulieu and Hughes (1977) shows that these older alluvial deposits extend upstream along both banks of the Rogue River for the entire length of the reservoir. Russell (1950) researched construction-era drawings and notes on file in the GPID Office and reported that cemented gravels form the foundation of the dam beginning at spillway bay 5 and extending north to the right abutment beneath the existing pumping plant. His report noted that outcrops of bedrock were observed protruding through the alluvium in the foundation of bays 4 and 5 and suggested that the alluvium cover overlying bedrock was very thin in this portion of the foundation. The thickness of the cemented gravel probably increases toward the right abutment, but no exploratory drilling has been performed in this area to determine the depth to the underlying Applegate Group metavolcanics.

The older terrace gravels (Qtg) are best known from exposures on the right abutment of the dam. Russell examined these outcrops in 1950 and described them as gravel and cobbles ranging from 25 to 150 mm (1 to 6 inches) in diameter, with scattered boulders from 300 to 600 mm (1 to 2 feet) in size. The matrix of the deposit was a mixture of sand, silt, and clay. The terrace gravels are only crudely stratified, and prominent

bedding planes are generally lacking. Upstream from the dam, discontinuous interbeds and lenses of sand and fine-grained silt and clay were noted along the shoreline during the 1999 field investigation.

Downstream from the dam, Russell (1950) noted that the terrace gravels (Qtg) were cemented with a fine-grained white material, possibly clay or silica. These exposures formed near vertical slopes and had experienced very little erosion since construction of the dam 30 years earlier. Inspection of these outcrops in 1999 confirmed Russell's observation. Goodson and Associates (1981) noted that the cementation appears to weaken when saturated and exposed, allowing the terrace gravel to yield more rapidly to erosion. This weakening of the cementation probably resulted in the erosion of a deep pothole along the downstream toe of the dam during the first 30 years of operation.

This pothole was backfilled and covered with a reinforced concrete apron during Reclamation's rehabilitation of Savage Rapids Dam from 1953 to 1955 (Goodson and Associates, 1981). Reclamation's Pacific Northwest Dive Team continues to perform periodic underwater examinations of the apron and adjacent area to monitor scouring and erosion of the cemented gravel foundation. Upstream from the dam, the degree of cementation within the terrace gravel is much more variable, and many areas appear to have little or no cementation. Russell (1950) noted that the terrace gravel is very compact and very difficult to dislodge with a pick, even where little or no cementation is present. The 1999 reservoir reconnaissance confirmed this observation and noted many areas along the shoreline where wave action had severely undercut the bank, resulting in very steep to overhanging banks, particularly along the north rim of the reservoir (see photograph 3). Exposures along the south shoreline are more limited because of the large number of structures along the water's edge, including revetments, retaining walls, docks, and slope protection.

Russell (1950) noted that the terrace gravels (Qtg) are overlain by a bed of alluvium upstream from the dam. This bed included scattered large boulders. This upper bed has not been differentiated for this study and is included within the terrace gravels. A review of published literature suggests that this upper bed may represent deposits left by the floods of 1861 and/or 1964. Beaulieu and Hughes (1977) mapped the extent of the floods based on limited field observations and data from a 1965 Corps study and show that extensive flooding occurred along the reservoir margin in both events. They report that the 1861 flood approximated a 100-year flood event, while the 1964 flood was on the scale of a 50-year event.

Younger Alluvium (Qal).—The younger alluvium (Qal) consists of alluvial materials deposited within the active channel of the Rogue River. These materials are primarily gravel, cobbles, and boulders mixed with lesser volumes of sand and very minor fines. In addition to channel deposits along the thalweg and active channel, the younger alluvium includes numerous bar deposits of chiefly gravel and cobbles, with sand and finer-grained bars of sand and silt along the margins of the active channel. The younger

*Photograph 3.—**Savage Rapids Dam, Rogue River Basin Project, Oregon**. View upstream toward the north bank of the reservoir near RM 107.0 showing exposures of the cemented terrace gravels and older alluvium. Wave action has eroded more weakly cemented materials near the base of the slope, forming a prominent overhang which is highlighted by a deep shadow in this photograph. Note the large volume of cobbles and boulders exposed along the shoreline in this section of the terrace gravels and older alluvium. (Reclamation photograph by Richard Link; May 18, 1999.)*

alluvium is best exposed along the banks of the Rogue River downstream from Savage Rapids Dam and upstream from the reservoir. Included within the younger alluvium are small alluvial fan/delta deposits within the main river channel occurring at the confluence of larger tributary streams.

The younger alluvium (Qal) is not present within the footprint of Savage Rapids Dam. Mapping and research of archival records by Russell (1950) suggest that the foundation was cleared of all loose material prior to construction of the dam. A pre-construction era photograph of Savage Rapids (see photograph 4), obtained from the Josephine County Historical Society in Grants Pass, Oregon, shows that the river channel at and upstream from the dam site consisted of a long riffle composed chiefly of cobbles, boulders, and bedrock knobs. Finer-grained deposits of gravel and sand may have been present upstream from the riffle but are not visible in the photograph.

*Photograph 4.—**Savage Rapids Dam, Rogue River Basin Project, Oregon**. A pre-dam view of Savage Rapids prior to construction of the dam in 1921 and 1922. The riffle seen in the photograph was named after the Savage family, who owned a homestead on the south or left bank of the Rogue River in this vicinity. Outcrops of metavolcanic rock of the Applegate Group are present in the foreground, while cemented terrace gravels and older alluvium form the north bank, seen in the distance. (Photograph courtesy of the Josephine County Historical Society, Grants Pass, Oregon.)*

Reservoir Sediments (Qrs).—The reservoir sediments (Qrs) consist of sediment impounded in the Rogue River behind Savage Rapids Dam since construction of the dam in 1921 and 1922. Because the primary focus of the 1999 Reclamation field investigation was the characterization of the materials composing the reservoir sediments and the determination of their distribution and extent, only a brief summary of these materials is presented here. The reservoir sediments are described in detail in the "Geology of Reservoir Sediments" section.

Test drilling conducted in the reservoir area by McLaren/Hart in 1998 and by Reclamation in 1999 established the presence of a very hard river bottom throughout the permanent reservoir pool, extending about 3,000 feet upstream from the dam. Complete refusal of the flight augers occurred during drilling wherever this river bottom was encountered. This refusal zone is assumed to represent the top of the pre-dam

riverbed for the purposes of this report. All materials overlying this hard river bottom have been incorporated within the reservoir sediments (Qrs), including any finer-grained younger alluvium (Qal) that may have been present in the Rogue River channel prior to construction of Savage Rapids Dam.

Geology of Reservoir Sediments

This section describes the physical character and extent of the sediments impounded behind Savage Rapids Dam, based on field samples and laboratory test data collected during Reclamation's investigation of the site in 1999. Data obtained in earlier studies of the site are incorporated in this discussion. A conceptual model has been developed to provide a framework for deposition of the sediments within the reservoir area.

Conceptual Model of Depositional Environment

A conceptual model for sediment deposition in the reservoir area is presented in this section to illustrate the logic used in the analysis of the sediment volume, discussed later in this report. (See "Sediment Volume.") This conceptual model is based on the observations made in the field during low reservoir level conditions in May 1999, the 1999 bathymetric surveys of the reservoir bottom, the borehole data collected during the field investigation, underwater observations, and a review of reservoir operations.

Reservoir Operation Summary.—The operation of the reservoir behind Savage Rapids Dam plays a key role in the accumulation of sediment upstream from the structure and must be accounted for in any model of sediment deposition. The concrete spillway section of the dam has a crest elevation of 957.6 (elevation 953.0 feet in the 1929 NGVD), which results in a permanent reservoir pool extending about 3,000 feet upstream from the dam to about RM 107.95, based on field observations of the upstream reservoir area made in May 1999. The permanent reservoir pool extends to just upstream from Savage Rapids Park, which is located on the south bank of the Rogue River at the confluence with Savage Creek.

The reservoir water surface is raised about 11.0 feet, to elevation 968.6 feet (elevation 964.0 feet in the 1929 NGVD), through the installation of stoplogs in the 16 bays along the spillway crest. This water surface increase results in a temporary pool which extends the reservoir approximately 15,000 feet farther up the Rogue River, to about RM 110.6, for the duration of the irrigation season. Stoplog installation typically occurs in about mid-May in a normal water year, but can vary, depending on the projected water supply from snow pack and the amount of spring precipitation supplying moisture to the irrigated farm land in the area (Dan Shepard, personal communication; September 1999). In 1992, the Rogue River Basin experienced drought conditions which required an earlier filling of the reservoir, permitting Reclamation to conduct its initial

survey of the reservoir under full reservoir pool conditions from April 21 through 24 (Blanton, June 12, 1992). To meet the downstream demand of the GPID, the reservoir is maintained at the full pool elevation for the duration of the irrigation season, which typically extends to about mid-October each year. As with installation, the timing for removal of the stoplogs varies, depending on the downstream water user needs and fall precipitation in the area. The stoplogs must be removed prior to the onset of the winter flood season to prevent damage to the stoplog brackets and loss of stoplog sections. Backwater effects of flooding with the stoplogs in place include inundation of private property along the upstream reservoir margin. The winter flood season commonly starts about November 1 of each year. With the removal of the stoplogs, the Rogue River is returned to free-flowing, riverine conditions upstream from Savage Rapids Park (upstream from approximate RM 107.95).

Sediment deposition within the reservoir impounded by Savage Rapids Dam occurs in response to the operational level of the reservoir pool. Operation of the reservoir water surface varies on a seasonal basis and results in two distinct and separate locales for sediment deposition:

- Deposition in the permanent pool immediately upstream from the dam during the irrigation off-season
- Deposition within the upper reservoir during the irrigation season

Each of these depositional locales is discussed separately in the following sections.

Deposition in the Permanent Reservoir Pool.—Sediment is deposited in the permanent reservoir pool upstream from Savage Rapids Dam following removal of the spillway stoplogs, permitting accumulation of sediment in the reach extending about 3,000 feet upstream from the dam to just above Savage Rapids Park, near RM 107.95. This sediment accumulation occurs from about mid-October to about mid-May each year and is associated with winter and early spring floods and the onset of the spring runoff within the river basin.

Reclamation's 1999 bathymetric survey of the Rogue River showed that the permanent reservoir pool is generally broad and flat bottomed, particularly in the reach from about RM 107.6 to the upper end of the permanent pool upstream from Savage Rapids Park, near RM 107.95. A contour map of the reservoir bottom for this reach of the river developed from the bathymetric survey appears on drawing 448-100-17. This reservoir bottom morphology strongly suggests sediment accumulation in this river reach. Test drilling completed by Reclamation in 1999 verified the sediment deposition suggested by the bathymetry and identified the presence of a buried pothole or pool at RM 107.91. The test drilling determined the bottom elevation of this pool to be at about elevation 924.0, which is 6.6 feet deeper than the deepest point of the dam foundation. Russell (1950) shows the lowest point in the foundation occurs at about elevation 930.6 (elevation 926.0 in the 1929 NGVD) near the junction of spillway bays 4 and 5 on his cross section of the dam. This cross section is based on original construction notes he

located in the files of the GPID. Since completion of the dam, sediment has completely filled this deep pool. Contaminant sampling conducted during the 1999 Reclamation field investigation was concentrated in this buried pool because it would have acted as a natural trap for any heavy metals and other contaminants migrating down the Rogue River from upstream mining districts. The results of the contaminant testing are discussed in Appendix C.

The Rogue River makes a prominent bend to the northwest at about RM 107.6, and the reservoir bottom morphology becomes more complex downstream from the bend. The south reservoir shoreline consists of continuous outcrops of metavolcanics from the Applegate Group (TrPzmv), and a prominent channel has formed along the contact between the bedrock and the reservoir sediments (Qrs). This channel extends downstream to the low-level outlet for the dam in spillway bays 10 and 11 and likely has formed in response to the annual opening of the outlet to permit installation of the stoplogs in the spillway bays. Opening of the low-level radial gates develops a high-velocity flow which likely scours the loose reservoir sediments upstream from the dam, forming the prominent channel seen in the bathymetry. The south side of the channel is lined with bedrock, while the north side consists of reservoir sediments which form a prominent bar along the north side of the reservoir, as shown in photograph 5. This bar has developed in response to lower velocities and current eddies on the inside curve of the bend in the river channel and extends downstream to Savage Rapids Dam (see the reservoir bathymetry on drawing 448-100-17). This bar, termed the north bar in this report, was the target of much of the drilling and testing conducted by McLaren/Hart in 1998. Drilling in the 1999 Reclamation field investigation was limited to a few holes to determine the configuration of the bar deposit as it tapers to the bedrock outcrops on the south side of the reservoir. This north bar and the sediments present upstream in the flat-bottomed reach of the permanent pool, discussed above, compose the bulk of the sediments that have accumulated behind Savage Rapids Dam.

A second bar deposit occurs on the south bank of the reservoir about 2,500 feet upstream from Savage Rapids Dam. This deposit, referred to as the south bar in this report, has formed over a prominent bedrock shelf along the water's edge. This bar appears to have accumulated in an eddy area of low velocity because most of the sediment in the deposit is fine sand and silt, with varying proportions of minor gravel and clay. McLaren/Hart conducted five explorations (SB-1 through -5, inclusive) in the south bar during their 1998 field investigation. The 1999 study by Reclamation did not further examine the south bar because the results of the earlier McLaren/Hart report (1998) appeared to adequately cover the extent of the deposit. The very shallow depth of water overlying the south bar also precluded access for Reclamation's floating drilling platform.

The storage capacity for additional sediment within the permanent pool behind Savage Rapids Dam is very limited because much of the reservoir has been infilled nearly to the crest elevation of the spillway. The infilling of the permanent pool is most visible on the north end of the dam, where the downstream end of the north bar laps onto the

*Photograph 5.—**Savage Rapids Dam, Rogue River Basin Project, Oregon**. View upstream showing the permanent pool upstream from the dam, drawn down for stoplog installation. This photograph illustrates the geology of the permanent pool, with bedrock outcrops of the Applegate Group present in the foreground along the south shoreline. These outcrops are buried by fine sand and silt forming the south bar in the distance. The north bar is exposed at the base of the opposite bank and is composed of variably mixed sand and gravel with cobbles which also compose much of the reservoir floor beneath the channel, shown in the center of the photograph. (Reclamation photograph by Richard Link; May 18, 1999.)*

spillway crest, as shown in photograph 6. This photo was taken in May 1999 at low pool conditions during installation of the stoplogs in the spillway bays. It clearly illustrates how the north bar sediments onlap the spillway section of the dam. Continued sediment storage is practical at only two locations within the permanent reservoir pool—the channel upstream from the low-level radial gate outlets, discussed above, and the intake to the pumping plant on the right end of the dam. The channel upstream from the radial gates represents the largest area available for additional sediment accumulation, but annual opening of the gates to permit stoplog installation under low pool conditions probably restricts the volume of significant permanent deposition within the channel. The high velocities generated within the reservoir when the low-level gates are opened probably flush any sediment accumulated in the channel and move it downstream from the dam on an annual basis. A small, conical depression in the configuration of the north bar was also observed immediately upstream from the pumping plant on the north end of the dam at the plant intake structure, as shown in photograph 7. This depression likely forms in response to operation of the plant during the irrigation season and,

*Photograph 6.—**Savage Rapids Dam, Rogue River Basin Project, Oregon**. View across Savage Rapids Dam toward the north bank showing the reservoir drawn down for installation of stoplogs across the spillway of the dam. Sediment has infilled the reservoir to the point that the north bar is lapping onto the concrete spillway, as can be seen in the distance, adjacent to the pumping plant. The bedrock outcrop forming the right abutment of the low-level radial gate outlet is exposed near the center of the photograph. (Reclamation photograph by Richard Link; May 18, 1999.)*

similarly to the low-level radial gates, the velocity of the water entering the pumping plant helps restrict the accumulation of sediment at this location. The depression at the plant intakes is small and represents a very small portion of the total volume of the permanent reservoir pool.

Based on these observations, the sediment storage space of the reservoir behind Savage Rapids Dam is essentially full and has been full for several decades. Therefore, the sediment loads being transported downstream from the dam are essentially equal to the loads being supplied to the reservoir from upstream. Currently, the sediment load of the Rogue River at Savage Rapids is less than the natural conditions because a significant portion of the natural sediment load is being trapped upstream in Lost Creek Reservoir.

Deposition in Temporary Reservoir Pool.—Deposition occurs in the temporary reservoir pool in response to installation of the stoplogs across the crest of the spillway.

*Photograph 7.—**Savage Rapids Dam, Rogue River Basin Project, Oregon**. View toward the north abutment of the dam and the pumping plant showing the conical depression formed in the surface of the north bar as a result of operation of the plant intakes. The reservoir is drawn down below the normal operational level to permit stoplog installation. Much of the surface of the north bar consists of a thin veneer of fine sand and silt which is similar to that observed upstream on the left shoreline at the south bar. (Reclamation photograph by Richard Link; May 18, 1999.)*

Deposition in the temporary reservoir is associated with the waning of the spring runoff, scattered summer thunderstorm flood events, and low flow periods on the Rogue River. Riverflows are regulated by the Corps at Lost Creek Dam, upstream from Savage Rapids. The temporary reservoir area is returned to free-flowing river conditions in the fall, when the stoplogs are removed from the spillway crest.

Bathymetric surveys show a change in the morphology of the reservoir bottom upstream from Savage Rapids Park, beginning at about RM 107.95. The river bottom transitions at this point from the generally broad, flat-bottomed profile, seen in the permanent reservoir area, to a series of steep riffles alternating with pools of varying depth. (See the reservoir bathymetry contour map included in attachment B.) This riffle-and-pool morphology of Appendix B appears to be characteristic of the temporary reservoir bottom. Prominent pools are observed in the reservoir bathymetry at RM 108.20, 108.87, 109.27, 109.67, and 110.22. The riffle-and-pool morphology observed in the temporary reservoir area is comparable to that observed in the 1999 Reclamation surveys of the Rogue River, downstream from Savage Rapids Dam to the confluence with the Applegate River. The bathymetric data suggest that sediments in the

temporary reservoir have not accumulated to the point that the pool sections have filled, as was observed downstream at RM 107.91 in test drilling conducted in the permanent reservoir area.

During the 1999 Reclamation field investigation, the Pacific Northwest Region Dive Team examined the temporary reservoir bottom to confirm that bottom conditions were as suggested by the bathymetry. Dive traverses were conducted at RM 108.72, 109.00, and 109.63, along with three spot observations in the permanent reservoir area. Their report is included as attachment D of this appendix. At RM 109.63, the reservoir bottom was composed chiefly of hard, subrounded cobbles, with bedrock outcrops present along the south bank. The outcrop continued underwater into the reservoir itself. The cobbles varied from 100 to 250 mm (i.e., 4 to 10 inches) in diameter and included minor gravel with very little sand. The coarse-grained character of the reservoir bottom continued downstream to the next traverse, located at RM 109.0. The divers reported a mix of cobbles and gravel at this traverse, with most of the material occurring as 75- to 200-mm (3- to 8-inch) diameter cobbles. They noted a maximum dimension of 300 mm (12 inches) in this traverse. As at RM 109.63, the traverse at RM 109.00 disclosed bedrock outcrops along the south bank of the river. The outcrops extended 50 feet north into the reservoir. The gravel and cobble deposit lapped onto the bedrock outcrop of hard metavolcanics at that point in the traverse. The traverse at RM 108.72 noted that the reservoir bottom consisted of hard, subrounded gravel and cobbles generally less than 125 mm (5 inches) in diameter. A maximum particle dimension of 250 mm (10 inches) was observed during the traverse.

These dive traverses document a very coarse-grained bottom in the temporary reservoir area upstream from Savage Rapids Dam and are consistent with the riffle-and-pool morphology observed in the bathymetric surveys. Photograph 8 shows coarse-grained gravel and cobble bars observed at a riffle near RM 109.6 during low reservoir pool conditions in May 1999. The dive observations indicate a trend of declining particle size with distance downstream, transitioning from predominantly cobbles in the upstream portion of the temporary reservoir at RM 109.63 to a finer-grained mix of gravel and cobbles at RM 108.72. These observations also suggest that significant sediment deposition does not occur in much of the temporary reservoir area when the reservoir water surface is elevated for the irrigation season. The coarse-grained materials observed in the dive traverses are high-energy deposits which accumulate in active river channels. Deposition of these materials cannot occur under elevated reservoir water surface conditions because the slack water of the reservoir lacks the energy required to transport the material. The coarse gravel and cobbles probably are deposited on a limited scale at the upper end of the reservoir, near RM 110.6, where the Rogue River enters Savage Rapids Reservoir. The low-velocity environment of the reservoir prevents any further movement of the material downstream until the end of the irrigation season, when the stoplogs are removed from the dam and the temporary reservoir is returned to free-flowing conditions. Material which has accumulated near RM 110.6 can then be moved downstream by winter storm events and spring runoff. This transport of coarse gravel and cobbles is generally restricted to storm events and high streamflows.

*Photograph 8.—**Savage Rapids Dam, Rogue River Basin Project, Oregon**. View upstream showing a prominent riffle exposed near RM 109.0. Reservoir pool elevation is lowered for stoplog installation. The bars exposed at this elevation consist chiefly of coarse gravel and cobbles indicative of a high-energy depositional environment. This portion of the reservoir is returned to free-flowing river conditions when the stoplogs are removed from the crest of the dam at the end of the irrigation season. These bars represent river channel deposition and are analogous to bar deposits seen elsewhere on the Rogue River upstream and downstream from Savage Rapids. (Reclamation photograph by Richard Link; May 18, 1999.)*

Low-flow periods are common during the irrigation off-season, and little transport of coarse materials can occur under these conditions. Many of the very large cobble sizes observed in the dive traverses, such as the 10- to 12-inch diameter material, probably are moved only during infrequent, large storm events where sufficient velocities can be generated to mobilize the coarse riverbed. The coarse-grained bed material observed in the dive traverses is better classified as river alluvium (i.e., younger alluvium - Qal, described earlier) than as reservoir sediment and is probably very similar to alluvial deposits present in the free-flowing portions of the Rogue River both upstream and downstream from Savage Rapids Reservoir.

Medium- and fine-grained sediment is deposited on a limited basis in the temporary reservoir area when the water surface is raised for the irrigation season. Operation of Savage Rapids Dam during the irrigation season includes flow over the dam through spillway bays 1 through 4, which is intended to attract migrating anadromous fish to

the north and south fish ladders (Dan Shepard, personal communication; September 1999). This flow is accomplished by leaving the topmost stoplogs out of each of the bays, resulting in a low-velocity current in the upstream reservoir. Although incapable of moving the coarse-grained bed material described above, the current does permit downstream transport of sand and fines into the reservoir. These finer-grained deposits occur mainly as a thin, discontinuous veneer on the reservoir bottom or as scattered small bars of sand and fines, as reported by the dive team. The dive traverse at RM 109.63, near the upstream end of the reservoir, did not observe any deposits of finer-grained material at that location. Mapping at the next downstream traverse, at RM 109.0, noted scattered, small bars composed of fine to medium sand. These small bars were localized and were less than 12 inches thick. Additional deposits of medium to coarse sand were observed at RM 108.72, where the sand occurred as irregular accumulations generally less than 15 feet in the longest dimension. These irregular deposits covered about 15 percent of the reservoir bottom at this location.

The finer-grained deposits were also noted at spot observations made farther downstream, within the permanent reservoir pool downstream from Savage Rapids Park. At RM 107.69, the divers noted a thin veneer of soft silt and organic debris covering the surface of the reservoir bottom. The veneer was from 4 to 6 inches thick. The surficial veneer continued downstream to RM 107.67, where the divers noted about 5 to 10 percent organic material in the veneer. The layer was about 2 to 9 inches thick and was underlain by a second layer of soft, medium- to fine-grained sand about 18 inches thick. The soft veneer of silt and organics was also described at the most downstream spot observation, RM 107.60. The thickness of the silt layer was measured to vary from about 1 to 2 inches thick at this spot observation.

Deposition of the finer-grained material in the temporary reservoir area is a transient process, active only while the water surface is elevated for the irrigation season, from about mid-May to about mid-October each year. Removal of the stoplogs returns the Rogue River to free-flowing conditions upstream from Savage Rapids Park. The finer-grained deposits are then flushed out of the temporary reservoir area by the higher velocity riverine environment, augmented by high-volume winter floods and spring runoff during the nonirrigation portion of the year. Mapping of the surface of the north bar, immediately upstream from the dam, during stoplog installation in May 1999 did not disclose any fine-grained deposits on the bar, suggesting that the winter floods are also capable of flushing the thin veneer seen in the permanent reservoir pool, particularly during large flood events. These fine-grained deposits are probably carried over the dam and downstream into the Rogue River during flood events.

Sediment Characterization

This section describes the physical properties and the soil types of the reservoir sediment based on field samples and laboratory testing conducted as part of the 1999

Reclamation evaluation of reservoir sedimentation. These data are then compared with results from previous studies at Savage Rapids Dam. A summary of the materials composing the south bar is included to complete this discussion of the reservoir sediments, although no new explorations were conducted at that site.

Summary of Physical Properties.—The following discussion of the physical properties of the sediments trapped in the reservoir behind Savage Rapids Dam is based on field observations of samples retrieved from the material and on laboratory tests conducted on representative field samples. Field descriptions and laboratory classifi-cations of the individual samples appear on the geologic logs of the drill holes in attachment B of this appendix.

Geologic mapping, observation of field samples, and laboratory testing indicate that the reservoir sediments at Savage Rapids Dam fall into one of three broad categories of materials:

- Mixed sand and gravel with 15 percent or greater gravel concentrations
- Sand with minor (less than 15 percent) gravel
- Sand with silt and minor clay

The mixed sand and gravel category constitutes the bulk of the reservoir sediment at Savage Rapids Dam, including both the floor of the permanent reservoir pool and the north bar. Samples collected in this area typically contain 15 to 56 percent gravel, by weight, and 30 percent is the average. Cobbles are also present in this material, as indicated by geologic mapping of the surface of the north bar and conditions encountered during drilling, including sampler refusal and infrequent recovery of particle sizes greater than 75 mm (3 inches) in diameter. Mapping of the surface of the north bar during low water conditions in May 1999 disclosed a variable cobble content ranging from about 20 percent, by volume, at the upstream end of the bar, gradually decreasing to about 5 percent at the downstream end, where the north bar lapped onto the spillway section of the dam, as shown on photograph 9. The maximum particle size observed on the bar was 250 mm (5 inches). The largest particle recovered from test drilling measured 110 mm (4.4 inches). Fines (very fine sand, silt, and clay passing the No. 200 sieve) occur in very low concentrations within the mixed sand and gravel category, ranging from 1 to 4 percent by weight and averaging 2 percent.

Sand with minor gravel occurs mainly within the buried pothole or pool at RM 107.91 (drill hole AP-99-3) and as apparently discontinuous lenses and layers in the north bar (AP-99-8). The gravel content in this group is significantly lower than in the mixed sand and gravel category, ranging from 5 to 13 percent by weight, with an average value of 8 percent. The maximum particle size recovered from these samples was 60 mm

*Photograph 9.—**Savage Rapids Dam, Rogue River Basin Project, Oregon**. View downstream toward Savage Rapids Dam showing the exposed surface of the north bar during stoplog installation on the spillway crest. This photograph shows the coarse-grained character of the sediments composing the north bar, which consists of variably mixed sand and gravel with cobbles. The volume of cobbles was field estimated at about 20 percent by volume at the upstream end of the bar, grading to about 5 percent at its downstream terminus at the spillway. This photograph shows the surface conditions near the approximate midpoint of the north bar. (Reclamation photograph by Richard Link; May 18, 1999.)*

(2.4 inches). No cobbles were present in the limited number of samples collected from this category. The fines content was very similar to that observed in the mixed sand and gravel category, varying from 1 to 3 percent by weight of the sample, with an average concentration of 2 percent.

Discussions held between Reclamation staff and peer reviewers while planning the field investigation determined that the fraction of soil particles finer than 0.063 mm in diameter (i.e., silt and clay particles passing the No. 230 sieve) was particularly detrimental to anadromous fish. This sieve size is not normally included in the standard Reclamation sieve set used to determine soil gradations but was included in this study to specifically address potential adverse impacts to the fisheries in the Rogue River. Results for individual samples are reported in the center column of the respective geologic logs in attachment B. Measured values for the minus 230 fraction are very low, as can be expected from the low concentrations for fines discussed above. The silt and clay particles compose only from 0.01 to 1.1 percent, by weight, of the samples of both

the mixed sand and gravel and the sand with minor gravel categories. The average silt and clay concentration for the samples was 0.2 percent.

Additional laboratory testing was conducted to determine the specific gravity of sand-, silt-, and clay-sized soil particles (i.e., those particles passing the No. 4 sieve) present in the field samples. The measured specific gravity of the mixed sand and gravel category ranged from a minimum of 2.666 to a maximum of 2.884, with an average of 2.729. Samples collected from the sand with minor gravel group had similar values, ranging from 2.685 to 2.740, and an average specific gravity of 2.719.

A qualitative assessment of the in-place conditions of the reservoir sediments can be made on the basis of field logging of soil samples and observation of downhole conditions during drilling operations. The density of the reservoir sediments ranges from low to moderate, as indicated by a generally rapid penetration rate of the auger string during drilling. Hard spots were noted in most holes, but these areas probably indicate the presence of cobbles within the deposit. Shallow refusal was attained in hole AP-99-4, where a large rock or buried log was encountered about 1.9 feet into the reservoir sediments. This hole was sited near the north shoreline of the reservoir and likely intercepted a section of riprap armor which had been dumped along the reservoir rim at this location. Refusal was also uniformly attained at the base of the reservoir sediments at or near the contact with the pre-dam bed of the Rogue River. The large diameters of the sample barrels used in this investigation precluded the use of the standard penetration test, but blowcounts were informally recorded for most sample intervals to attain a relative gauge of the in-place density of the sediments. Blowcounts ranged from a minimum of 3 blows per foot (bpf) to a maximum of 33 bpf in the 25 test intervals where penetration was recorded. The average blowcount for these tests was 17 bpf. These data further suggest that the reservoir sediments have a low to moderate in-place density and that the deposits would be readily susceptible to erosion under free-flowing river conditions in the event that Savage Rapids Dam is removed. Note that higher blowcounts were obtained where the sample intervals intercepted the pre-dam riverbed, but these intervals are not included in the statistics presented above. The refusal intervals were commonly characterized by the sample barrel rebounding with no penetration under the weight of the 350-pound hammer falling a distance of about 30 inches. Testing was uniformly discontinued once sampler refusal was achieved.

The reservoir sediments are massive to crudely stratified, and bedding planes were generally lacking in most samples. Most of the samples were field logged as hetero-geneous (27 of 32 samples), while 1 was described as homogeneous. Four samples were logged as stratified, with the thickness of individual layers varying from 90 to 500 mm (0.3 to 1.7 feet). Note that the entire thickness of the individual layers was not recovered, and these reported thicknesses are minimum values. Only the top and bottom of each layer were sampled, and generally a gap of at least 1 foot was left between samples.

The reservoir sediments present on the reservoir floor and in the north bar probably have a relatively high permeability, based on the gradations obtained during laboratory

testing and the very small concentration of fines present in the material. This interpretation is supported by field observation of the north bar during low water conditions while stop-logs were being installed in May 1999. The sand and gravel composing the north bar drained rapidly with lowering of the reservoir pool. The bar surface was mapped within 3 to 4 hours of exposure of the bar as the reservoir lowered and much of the area drained. The bar surface supported foot traffic during mapping and had drained sufficiently so that footprints did not form on the bar, except in the more sandy materials at the downstream end of the bar. Because of the relatively low in-place density of the deposit, the bar surface probably would not have supported heavy equipment travel without prolonged exposure.

The third category of materials present in the reservoir behind Savage Rapids Dam consists of sand with silt and minor clay. These materials form the south bar along the left reservoir rim and also occur as a surficial layer in the immediate proximity of the surface depression at the pumping plant intake structure on the right end of the dam. These materials were not encountered in the 1999 field investigation conducted by Reclamation, and present knowledge of the materials is based on the data collected by McLaren/Hart (1998). Field descriptions of these materials indicate the deposit consists chiefly of sand and silt, as shown on the borehole logs included in their report. Gravel concentrations were estimated in the field at up to 10 percent in several of the samples. Photograph 10 shows the exposed surface of the south bar during low reservoir pool conditions while stoplogs were being installed across the spillway crest in May 1999.

Distribution of Soil Types.—Reclamation's 1999 field investigation collected a total of 32 samples of the reservoir sediments stored behind Savage Rapids Dam. Of these samples, 25 were deemed representative of the deposit based on sample recovery and were submitted for laboratory testing to determine standard physical properties. The samples were assigned soil types based on the USCS (Reclamation, 1990, Designation USBR 5000-86) derived from analysis of sieve data obtained in the laboratory tests. The laboratory data have been reported on the respective geologic logs of the drill holes appearing in attachment B and have been compiled on gradation test charts which have been included in attachment C.

Table 1 lists the laboratory soil classifications of the reservoir sediment and the computed fraction of the deposit represented by each soil type, based on the total number of samples collected.

Table 1.—Distribution of reservoir sediment soil types at Savage Rapids Dam

Soil type	SP	(SP)g	(SW)g	(GP)s	(GW)s
Number of samples	5	13	3	3	1
Percent of deposit	20	52	12	12	4

*Photograph 10.—**Savage Rapids Dam, Rogue River Basin Project, Oregon**. View upstream showing the surface of the south bar as exposed while the reservoir pool was low during stoplog installation. The south bar consists of fine sand and silt, based on earlier explorations by McLaren/Hart (1998) and is underlain by bedrock of the Applegate Group at depths ranging from 6.5 to 14.8 feet in five test borings drilled at this site. (Reclamation photograph by Richard Link; May 18, 1999.)*

In the "Sediment Characterization" section of this appendix, reservoir sediments were subdivided into three broad categories of materials, only two of which were encountered during the 1999 Reclamation field investigation. The mixed sand and gravel category consists of materials having the following laboratory classifications from table 1: poorly graded sand with gravel (SP)g, well-graded sand with gravel (SW)g, poorly graded gravel with sand (GP)s, and well-graded gravel with sand (GW)s. The sand with minor gravel category is represented by poorly graded sand (SP) in table 1.

Average gradations were computed for both the mixed sand and gravel and the sand with minor gravel categories for use in computer modeling of erosion and downstream transport of the reservoir sediments in the event that Savage Rapids Dam is removed. Figure 2 also includes derived laboratory soil classifications for each average gradation and tabulates the percentages of gravel, sand, and fines.

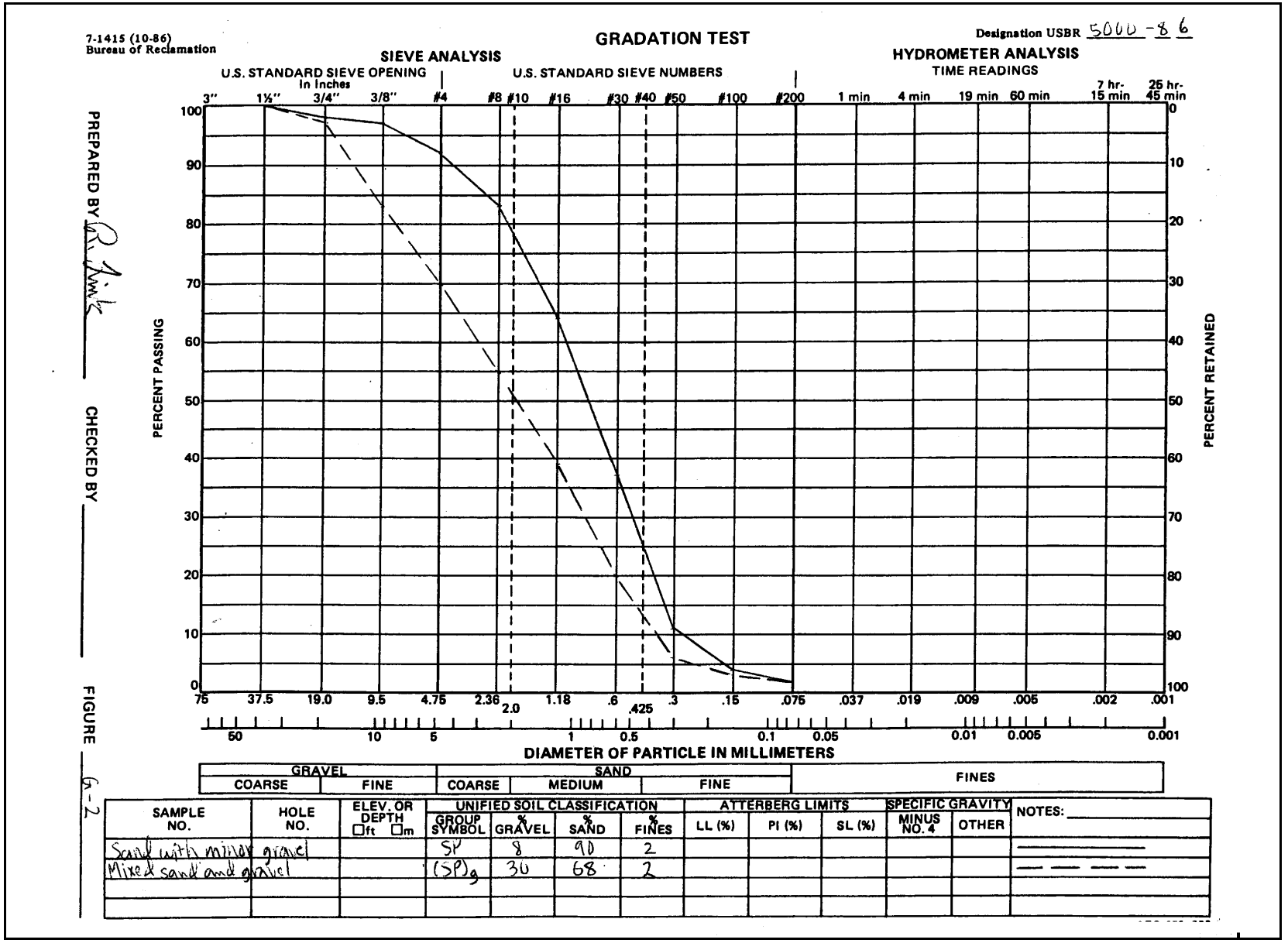

Figure 2.—Computed average gradations for reservoir sediments at Savage Rapids Dam.

The laboratory test data were analyzed for both the mixed sand and gravel and the sand with minor gravel categories to assess the variation in mean particle diameter, or D50, in the field samples (table 2). This diameter is useful in evaluating erosion and transport of the reservoir sediments under a dam removal scenario.

Table 2.—Variation of D50[1] (in mm) in reservoir sediments at Savage Rapids Dam

Soil category	$D50_{max}$	$D50_{min}$	$D50_{avg}$
Mixed sand and gravel	6.20	0.51	2.35
Sand with minor gravel	1.10	0.61	0.84

[1] The mean particle diameter, or D50, is an expression of the average particle size of a sediment obtained graphically by locating the diameter associated with the midpoint of the particle-size distribution; the D50 is the middlemost diameter that is larger than 50 percent of the particle size distribution for a given sample and smaller than the other 50 percent; the mean particle diameter is commonly expressed in millimeters. The $D50_{max}$ is the largest D50 diameter observed in all gradation tests for a soil category, while the $D50_{min}$ is the smallest D50 diameter; the $D50_{avg}$ is the computed average for all D50 diameters calculated for a soil category.

Reclamation's 1999 field investigation was conducted to expand upon earlier work that was performed by McLaren/Hart (1998) at the site. Comparison of the data collected by Reclamation with field descriptions of the reservoir sediments appearing on the geologic logs of boreholes in the McLaren/Hart report shows a close correlation of materials in the reservoir area and in the north bar. A comparison of laboratory test data for the reservoir sediment was also planned, but the records for the earlier work could not be located (Edward Fendick, personal communication; October 1999) and have not been incorporated into the discussions presented in this report. Table A2-1 of the McLaren/ Hart report (1998) does include a list of the percent of silt and clay particles passing the No. 230 sieve. Table 3 compares the data from the McLaren/ Hart report with that obtained in 1999 by Reclamation. The Reclamation data collected from the reservoir floor and the north bank correlate well with the McLaren/Hart data, as can be seen in table 2. Data for the south bank obtained by McLaren/Hart are also included in the table because this area provided the highest concentration of silt and clay observed at Savage Rapids. The south bar was not tested in the Reclamation program, and no new data are available.

Sediment Volume

One of the objectives of the 1999 Reclamation field investigation was to develop a more refined estimate of the volume of reservoir sediments stored behind Savage Rapids Dam. The estimate was based on the bathymetric surveys of the reservoir basin and the measured thicknesses of sediment determined from test drilling. This section discusses

Table 3.—Summary of reservoir sediment silt/clay content at Savage Rapids Dam

Percent fines (% passing No. 230 sieve)	Reservoir floor and north bar		South bar
	McLaren/Hart (1998)	Reclamation (1999)	McLaren/Hart (1998)
Minus No. 230_{max}	2.5	1.1	20.7
Minus No. 230_{min}	0.1	0.01	0.2
Minus No. 230_{avg}	0.7	0.2	7.5

the methodology used to develop the estimate, presents the results of the volumetric analysis, and provides further discussion of the volume of material per soil type present in the reservoir sediments.

Method.—The estimate of the volume of reservoir sediment stored behind Savage Rapids Dam was prepared using a series of 20 geologic cross sections drawn through the permanent reservoir pool, extending upstream from the dam to about RM 107.95. The locations of the cross sections are shown on the bathymetric map of the reservoir on drawing 448-100-17 in attachment A of this report. The individual cross sections appear on drawings 448-100-18 and -19. The topography of the reservoir bottom shown on the cross sections is drawn from Reclamation's 1999 bathymetric survey. The geometry of the sediment prism was approximated using the measured thickness of the sediments as determined from exploratory drilling, including both the earlier work by McLaren/Hart (1998) and the 1999 explorations completed by Reclamation. The lateral limits of the sediment prism were approximated by projecting the side slopes of the reservoir down until the bottom elevation of the drill hole was intercepted, as illustrated on sections A-A' and L-L' (see drawings 448-100-18 and -19, respectively). The end area of the sediment prism on each cross section was then computed using AutoCad version 14. Note that the computed end areas for the sediment prisms are shown on each cross section. Volume segments were then calculated by projecting each end area half the lateral distance upstream and downstream to the next available cross section.

Additional cross sections were drawn where large distances separated individual drill hole data. The bottom of the reservoir sediments was then approximated by averaging the base elevations of drill holes on adjacent sections upstream and downstream (see section P-P' on drawing 448-100-19 as an example).

In many cross sections, the projection of one or both of the reservoir side slopes intercepted the drill holes above the bottom elevation of the hole, indicating that the reservoir side slopes must steepen at some unknown point below the surface of the sediments. The sediment prism was adjusted by arbitrarily selecting a distance midway between the drill hole stick log on the cross section and the assumed contact of the reservoir side slope with the top of the reservoir prism. The base elevation of the drill

hole was then extended laterally to this arbitrary point and the side slope was connected to the arbitrary point to define the side of the sediment prism, as shown on cross section B-B'. Several cross sections required adjusting both sides of the sediment prism to reach the base elevation of the drill hole. This system effectively averages the difference in observed elevations of the sediment prism and is repeatable from section to section but may introduce some error into the end area computations. A review of the affected cross sections indicates that this adjustment is conservative and probably overestimates the calculated end areas in most instances. Further definition of the sediment prism geometry can be accomplished only with additional exploration at the site and is probably not warranted based on (1) the limited improvement to the volume estimate that could be attained through this work and (2) the anticipated costs that would be incurred for the investigation.

Cross section A-A' is the first section drawn upstream from the dam and requires additional explanation. The base of the sediment prism is shown deeper than the depth of refusal recorded for drill hole NB-2 (McLaren/Hart, 1998). The base elevation was adjusted to the bottom of the dam reported by Russell (1950) to account for that portion of the reservoir sediment between the cross section and the dam which is deeper than hole NB-2. This adjustment overestimates the volume of sediment present upstream from the cross section, but accounts for sediment downstream of the cross section that would otherwise have been left out of the estimate. Savage Rapids Dam includes a series of seven inclined concrete arches beneath spillway bays 1 through 7, which extend upstream from the dam and slope downward to intercept the old river bed about 50 feet upstream from the structure. The volume computation for cross section A-A' does not take these arches into account, and the volume of the arches has been included with that calculated for the reservoir sediments. The volume of the concrete arches is relatively small compared to that computed for the reservoir, and its inclusion does not significantly impact the volume estimate.

The volume estimate also includes computation of the materials composing the south bar, based on the drill hole data obtained by McLaren/Hart (1998). This volume was estimated using the methodology described above. The south extent of the deposit is poorly constrained because the south bar extends into the shoreline, and portions of the deposit lie beyond the reservoir margin and outside the bounds of the bathymetric survey. The southern extent of the deposit was approximated from aerial photographs and field notes taken during reconnaissance of the reservoir. The surface of the deposit was extended to the left on cross sections H-H' and I-I' to account for the presence of materials beyond the present reservoir limits, as indicated by dashed ground lines on the cross sections. The volume estimate for the south bar probably contains the highest potential error of any of the computations for Savage Rapids because of the uncertainty of the southern limits of the deposit.

Volume Estimate.—The end areas, projected lateral distances, and computed volume segments described in the preceding section were compiled in an Excel spreadsheet to

obtain an estimate of the total sediment volume present in the reservoir upstream from Savage Rapids Dam. These data are summarized in table 4. The total volume of reservoir sediment present behind Savage Rapids Dam is estimated at approximately 200,000 yd^3, including the south bar.

This estimate differs from the previous Reclamation volume estimate (Blanton, June 12, 1992) in a key area. The previous study assumed sediment accumulation for the entire length of the temporary reservoir pool for computation of the volume of sediment stored behind Savage Rapids Dam and did not account for the seasonal operation of the reservoir. Bathymetric data collected in 1999 shows that the reservoir bottom in the temporary pool consists of a series of riffles and pools. This reservoir bottom morphology is not consistent with significant sediment accumulation which would result in infilling of the pool reaches, as presented in the conceptual model of sediment deposition. Dive traverses conducted in the temporary pool in 1999 demonstrate that the reservoir bottom consists chiefly of coarse-grained gravel and cobbles which are representative of high-energy river channel conditions, not the slack-water environment expected in a reservoir. These coarse-grained deposits are analogous to alluvial deposits present in the river upstream from the reservoir and to those that were probably present in the Rogue River prior to construction of Savage Rapids Dam.

These observations do not support significant reservoir sediment accumulation in the temporary reservoir pool from RM 107.95 to the upstream end of the reservoir near RM 110.6. Limited sediment deposition occurring while the reservoir is elevated to the temporary pool level is most likely eroded out and moved downstream once that section of the reservoir is returned to free-flowing river conditions at the end of the irrigation season and the temporary pool area is exposed to winter floods and the spring runoff.

Additional discrepancy in the sediment volume resulted from the method that Blanton (June 12, 1992) was forced to use. The method normally used to compute sediment volume relies on having the pre-dam topography, which is not available for Savage Rapids. Lacking any pre-dam topography of the reservoir area, drill hole data, dive examinations, or geomorphic investigations, Blanton averaged the slope or gradient of the Rogue River through the reservoir to define the pre-dam elevation of the riverbed. He used 1923 USGS contour data to establish the upstream end point above the reservoir and site topography for Savage Rapids Dam to define the riverbed elevation at the downstream end. Comparing this estimated slope with the 17 measured cross sections he obtained in 1992, Blanton assumed that any 1992 data with elevations higher than his estimated pre-dam riverbed slope represented sediment accumulation within the reservoir. Field data collected in 1999 for the present study, including the bathymetric surveys and dive observations, demonstrate that the Rogue River channel consists of a series of relatively steep riffles alternating with generally flat pool sections rather than the gently sloping gradient estimated by Blanton. The effect of the sloping gradient is to overestimate the sediment volume because relatively extensive high spots in the river channel formed by cobble and boulder armoring or bedrock outcrops that

Table 4.—Estimated volume of reservoir sediments at Savage Rapids Dam

Geologic section	Reservoir floor and north bar				South bar			
	End area (ft^2)[1]	Length u/s[2] (feet)	Length d/s[3] (feet)	Volume (ft^3)[4]	End area (ft^2)	Length u/s (feet)	Length d/s (feet)	Volume (ft^3)
A-A'	3,042	25.9	79.9	321,844	0	0	0	0
B-B'	2,611	30.5	25.9	2,611	0	0	0	0
C-C'	2,123	62.7	30.5	197,864	0	0	0	0
D-D'	1,919	69.4	62.7	253,500	0	0	0	0
E-E'	2,319	71.4	69.4	326,515	0	0	0	0
F-F'	2,003	75.3	71.4	293,840	0	0	0	0
G-G'	2,311	75.5	75.3	348,499	0	0	0	0
H-H'	2,625	52.3	75.5	335,475	137	72.4	92.3	22,564
I-I'	2,087	59.6	52.3	233,535	715	72.3	72.4	103,460
J-J'	2,109	55.4	59.6	242,535	447	74.1	72.3	65,441
K-K'	1,011	46.6	55.4	103,122	418	58	74.1	55,218
L-L'	1,000	78.2	46.6	124,800	696	94.6	58	106,210
M-M'	1,993	71.6	78.2	298,551	635	83.4	94.6	113,030
N-N'	1,365	83.5	71.6	211,712	0	0	0	0
O-O'	1,995	108.8	83.5	383,639	0	0	0	0
P-P'	2,199	109.5	108.8	480,042	0	0	0	0
Q-Q'	1,930	102.6	109.5	409,353	0	0	0	0
R-R'	547	104.8	102.6	113,448	0	0	0	0
S-S'	262	97.4	104.8	52,976	0	0	0	0
T-T'	149	97.4	97.4	29,025	0	0	0	0
		Subtotal (ft^3)		4,762,885				465,923
		Total volume (ft^3)						5,228,808
		Total volume (yd^3)						193,660

[1] Square feet.
[2] Upstream from geologic section.
[3] Downstream from geologic section.
[4] Cubic feet.

are resistant to erosion are included in the sediment computations. Blanton (June 12, 1992) estimated a volume of 320 acre-feet (516,267 yd^3) for the sediments stored behind Savage Rapids Dam, which is more than double the quantity estimated in the present study.

McLaren/Hart (1998) measured the thickness of the reservoir sediment at the north and south bars and prepared a volume estimate based on that data. Their calculated volume for that portion of the reservoir was 138,000 yd^3 of sediment. A comparison with the earlier study by Blanton (June 12, 1992) showed that McLaren/Hart's volume calculation was about 2.5 times that of Blanton's estimate for the same portion of the reservoir. Based on this difference in volumes, McLaren/Hart estimated that the total sediment volume for the entire reservoir, including the temporary pool area, could vary from 600,000 to 1,000,000 yd^3. The volume estimate prepared for the present Reclamation study agrees well with that of McLaren/Hart for the portion of the reservoir encompassing the north and south bars (i.e., cross sections A-A' through M-M', inclusive, in table 4). The total volume calculated in the present study is slightly less than 137,000 yd^3 for the same reach of the reservoir that was examined by McLaren/Hart. The primary difference between the McLaren/Hart study and the present study is that the McLaren/Hart estimates used Blanton's (June 12, 1992) assumption that sediment deposition occurred within the entire length of the reservoir, including the temporary pool area. Data collected for the present study do not support significant sediment accumulation in the temporary pool upstream from Savage Rapids Park, as discussed above. These data indicate that sediment deposition is only significant in the permanent pool which extends from Savage Rapids Dam upstream to the park, and this difference results in a considerably smaller sediment volume than in either of the previous two studies.

Volume per Soil Type.—Using the total estimated volume of sediment present in the reservoir at Savage Rapids calculated in table 4, an additional analysis was performed to evaluate that volume distributed among the various soil types identified within the reservoir sediment. This analysis used the distribution of reservoir sediment soil types shown in table 1 and estimated the volume of each type. The soil types present in the south bar have been approximated based on field descriptions of the materials reported on the respective geologic logs for drill holes SB-1 through -5 in McLaren/Hart (1998) and the laboratory test data available for the minus No. 230 fraction of the samples. These materials are listed as silty sand (SM) and sandy silt s(ML) in table 5.

Table 5.—Distribution of reservoir sediment volume per soil type

	SP	(SP)g	(SW)g	(GP)s	(GW)s	SM & s(ML) [1]
Volume (yd^3)	36,352	94,516	21,811	21,811	7,271	17,256

[1] Estimated composition of south bar materials based on field descriptions in McLaren/Hart (1998).

Conclusions and Recommendations

The reservoir sedimentation investigation conducted by Reclamation in 1999 included bathymetric mapping to determine the geometry of the reservoir bottom, recon-naissance geologic mapping of the reservoir rim during low reservoir pool elevation, drilling of 12 exploration holes to measure the thickness of reservoir sediments and determine their composition, and underwater mapping to document reservoir bottom conditions, particularly in the upper reach of the reservoir. This investigation demonstrates that the reservoir sediments are predominantly a variable mixture of coarse-grained sand and gravel with cobbles. Fines consisting of very fine sand, silt, and clay are present in very low concentrations in the dominantly coarse-grained deposit. These data agree well with previous investigations conducted at the dam by McLaren/Hart in 1998. Finer-grained deposits of silty sand and sandy silt are present at the south bar on the left reservoir rim upstream from the dam and as a thin veneer at the intake of the pumping plant located on the right abutment of the dam. These materials compose less than 10 percent of the total volume of sediment present behind Savage Rapids Dam.

The total volume of sediment stored behind Savage Rapids Dam is estimated at approximately 200,000 yd^3, based both on data collected in this investigation and on previous investigations at the site. Data and field observations obtained for this study do not support significant sediment accumulation in the temporary reservoir pool formed between RM 107.95 and RM 110.6 when the stoplogs are installed across the crest of the dam. While discontinuous bars of sand and silt were observed on the reservoir bottom in this reach, these deposits probably do not survive exposure to winter floods and spring runoff when the stoplogs are removed and the reservoir is returned to free-flowing river conditions at the end of the irrigation season. Under-water examination of the bottom conditions of the temporary pool area show the reservoir floor is chiefly coarse-grained gravel and cobbles which are too large to be transported in the low-energy, slack-water conditions prevalent in the reservoir. These deposits are more analogous to the river channel deposits present in the Rogue River upstream and downstream from the reservoir pool.

Because the current study indicates that upon removal of Savage Rapids Dam there would be less sediment released than originally anticipated, all downstream effects would be less than indicated in the *Planning Report/Final Environmental Statement (PR/FES), Fish Passage Improvements, Savage Rapids Dam, Josephine Water Management Improvement Study,* completed in 1995.

The bathymetric surveys show that the permanent reservoir pool, extending about 3,000 feet upstream from the dam to RM 107.95, near Savage Rapids Park, has very little capacity to store additional sediment. The reservoir at Savage Rapids is essentially full and has been full for several decades. Sediment loads transported by the Rogue River downstream from the dam are essentially equal to the upstream supply. The present

upstream supply to the reservoir is less than the natural historic load because a significant portion of the natural sediment load is being trapped upstream in Lost Creek Reservoir.

Additional exploration of the pumping plant sites proposed as the preferred alternative to replace Savage Rapids Dam should be considered. Investigations of Savage Rapids Dam (Russell, 1950) show that the north end of the dam foundation consists of variably cemented gravel and cobbles which historically have been susceptible to scouring and erosion. Site explorations should be conducted to determine if these cemented gravels are present in the foundations of the pumping plants and to evaluate the depth beneath the gravels to competent bedrock.

References

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Attachment A

GEOLOGIC DRAWINGS

GENERAL GEOLOGIC LEGEND

Qrs — Holocene Reservoir Sediments. Post–Savage Rapids Dam reservoir sediments deposited by the Rogue River and its tributary streams. Consists chiefly of variably mixed sand and gravel with cobbles; includes interbeds and lenses of sand with minor gravel and prominent bar on left or south reservoir rim composed of sand and silt with minor clay. Massive to crudely stratified with bedding planes generally lacking in recovered samples; thickness of individual layers varies from 0.3 to greater than 2 ft (maximum sample length). Maximum thickness is about 20 ft in both the north bar along the right reservoir rim upstream of the dam and in a buried pool or pothole about 300 ft upstream of the north bar.

Qal — Quaternary Younger Alluvium. Unconsolidated river channel alluvium and bars deposited by the Rogue River and its tributary streams. Consists chiefly of gravel, cobbles and boulders with sand and minor silt; described on basis of exposures upstream and downstream from reservoir as explorations uniformly attained refusal at top of unit. Construction records indicate that unit was stripped from foundation prior to construction of Savage Rapids Dam.

Qtg — Quaternary Terrace Gravel and Older Alluvium. Older alluvium of the Rogue River forming prominent terraces flanking reservoir margins. Consists chiefly of gravel and cobbles with boulders in a matrix of sand, silt and clay; crudely stratified with prominent bedding planes lacking; layers and lenses of sand, silt and clay observed along reservoir shoreline upstream from dam. Variably cemented with silica and/or clay, forming relatively flat to very steep to overhanging banks along the reservoir rim. Forms foundation of dam right of spillway bay 5; subject to erosion and scouring along downstream toe of dam; thickness of unit in dam foundation is unknown.

TrPzms — Paleozoic to Triassic Metasediments. Metamorphosed and altered sedimentary rocks of the Applegate Group. Consists chiefly of metaconglomerate in submerged outcrops observed in the reservoir about 1300 ft upstream of Savage Rapids Dam; unit is not exposed in surface outcrops along the reservoir rim.

TrPzmv — Paleozoic to Triassic Metavolcanics. Metamorphosed and altered volcanic rocks of the Applegate Group. Consists chiefly of greenstone with interbeds of serpentine in the vicinity of Savage Rapids Dam with a fine–grained groundmass lacking prominent crystals or inclusions; generally slightly weathered and hard, requiring a heavy hammer blow to break field specimens; typically slightly to very slightly fractured with fracture surfaces spaced about 1 to 4 ft apart. Unit forms the foundation and left abutment of the dam and extends about 1100 ft upstream of the dam along the left or south rim of the reservoir.

GENERAL GEOLOGIC EXPLANATION

DH–90–20 ● — Drill hole location and number.

A — A' — Location of geologic section.

— — ?— — Geologic contact. Queried where inferred. Dotted where concealed.

1011 sq ft — Calculated end area for prism of reservoir sediment.

DH–90–20
EL 3220.5
(Proj 11' N) — Drill hole number, elevation at ground surface at collar of drill hole, and distance and direction of projection.

Stick log of drillhole. dashed when projected more than ten feet to the section.

Qrs — Geologic symbol.

83.5 — Total depth of drill hole.

GENERAL GEOLOGIC NOTES

1. Geologic descriptors used in this report are defined in the "Engineering Geology Field Manual", Second Edition, Volume 1 (U.S. Bureau of Reclamation, 1998).
2. The Unified Soil Classification System (Designations USBR 5000–86 and 5005–86; U.S. Bureau of Reclamation, 1990) was used to describe nonindurated, uncemented earth materials sampled in the explorations; letter classification symbols shown on the logs are group symbols of the Unified Soil Classification System based on field and laboratory classifications.
3. General Geologic Legend, Explanation and Notes to accompany the following drawings:

   448–100–17 448–100–18 448–100–19
4. The survey control appearing on the accompanying drawings uses horizontal control from the NAD 1983, Oregon South State Plane Zone 3602 and vertical elevations from the NAVD 1988 datum. Elevations based on the older NGVD 1929 vertical datum have been converted to the NAVD 1988 using a factor of +4.6 ft, based on USBR field surveys conducted at the dam in 1999.

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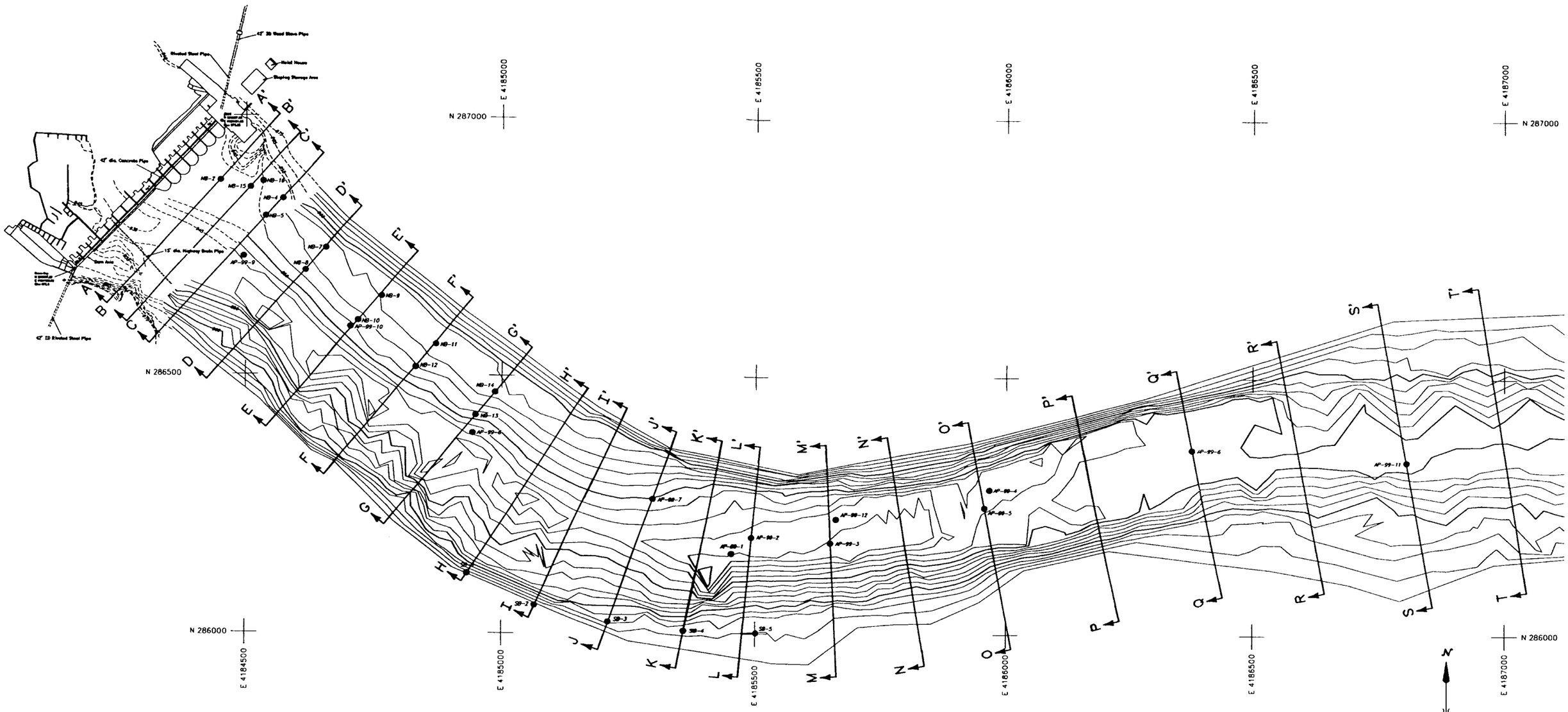
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

ROGUE RIVER BASIN PROJECT – OREGON

SAVAGE RAPIDS DAM

GENERAL GEOLOGIC LEGEND, EXPLANATION AND NOTES

GEOLOGY R.J.INK		
DRAWN T.ENGLAND	TECH APPROVAL	
CHECKED	APPROVED (PROGRAM MANAGER)	
CADD SYSTEM ACAD v14	CADD FILENAME	DATE PLOTTED 4-11-00
BOISE, IDAHO	NOVEMBER 1999	448–100–16



Notes:

1. Refer to dwg 448-100-16 for General Geologic Legend, Explanation and Notes.
2. Refer to dwg 448-100-18 for geologic sections A-A' through K-K' inclusive.
3. Refer to dwg 448-100-19 for geologic sections L-L' through T-T' inclusive.
4. Outline of dam and appurtenant structures taken from dwgs 1313-D-1 and -2 using 1999 USBR field surveys to established the dam within the 1983 NAD and 1988 NAVD State Plane grid, Oregon South Zone.
5. Dashed contours within the forebay area are taken from 1972 contours shown on dwgs 1313-D-1 and -2, as no 1999 bathymetric surveys were conducted in the forebay. The 1972 contour elevations have been adjusted to the 1988 NAVD datum using a conversion factor of +5 feet.
6. The locations of McLaren / Hart drill holes (designations NB- and SB-) are based on field survey data by Max H. Hull Land Surveying with permission from Sportfish Heritage, Inc. Holes not included in the survey have been best fit using the sketch map in the McLaren / Hart report (1998).
7. Elevations of the McLaren / Hart drill holes have been adjusted to the 1988 NAVD datum using a conversion factor of +4.6 feet, based on 1999 USBR field surveys at the dam.

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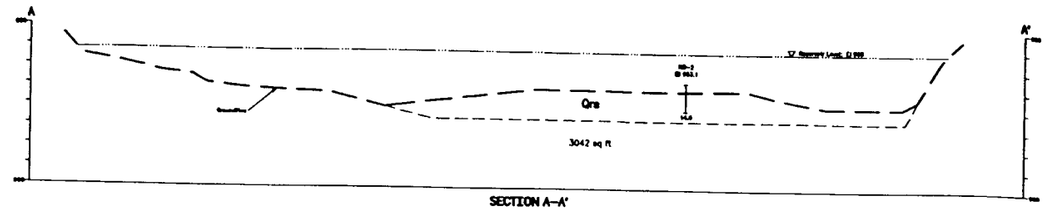
BUREAU OF RECLAMATION

ROGUE RIVER BASIN PROJECT - OREGON

SAVAGE RAPIDS DAM
SEDIMENTATION STUDY
BATHYMETRIC MAP OF PERMANENT RESERVOIR AND LOCATIONS OF EXPLORATIONS AND SECTIONS

GEOLOGY R.LINK		
DRAWN T.ENGLAND	ITCH APPROVAL	
CHECKED	APPROVED PROGRAM MANAGER	
CADD SYSTEM ACAD v14	CADD FILE NAME (drawings\dgn\448-17.dgn)	DATE PLOTTED 4-11-00
BOISE, IDAHO NOVEMBER 1999 SHEET 1 OF 1		448-100-17



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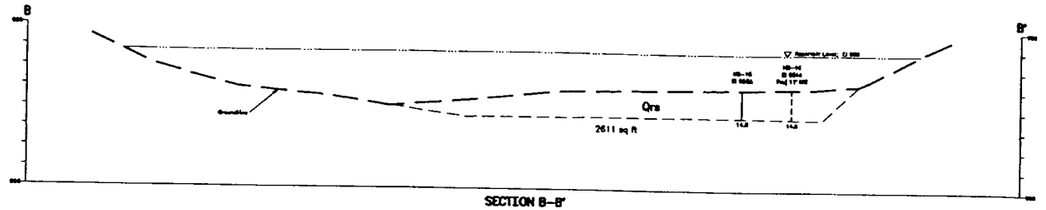
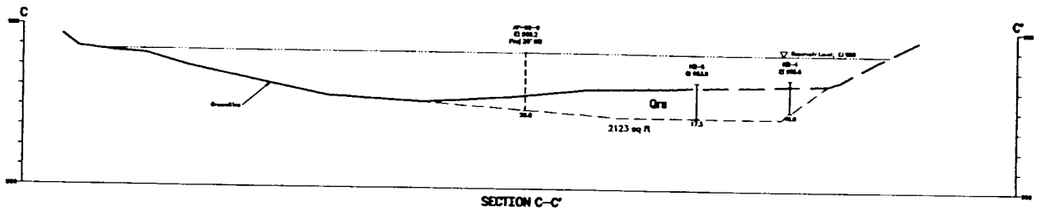


SECTION B–B'



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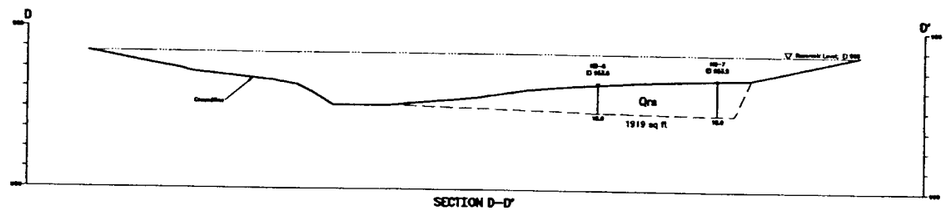
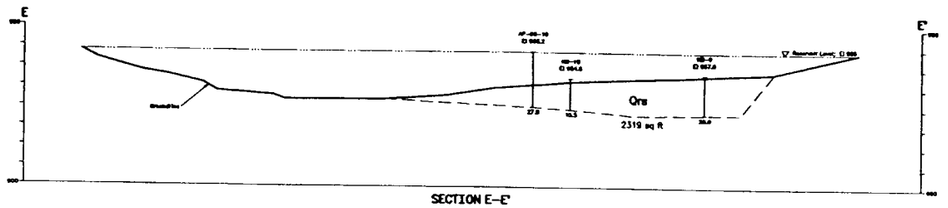
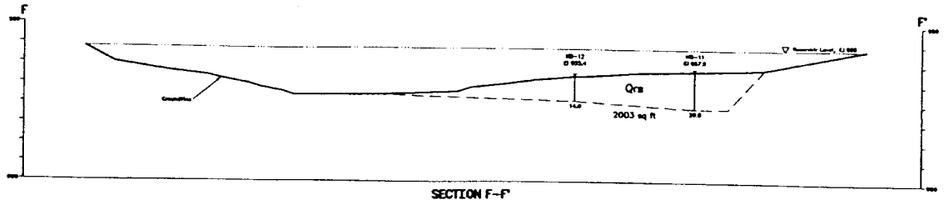


SECTION D–D'



SECTION E–E'



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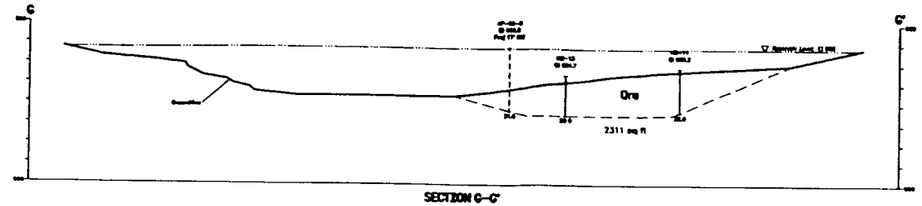
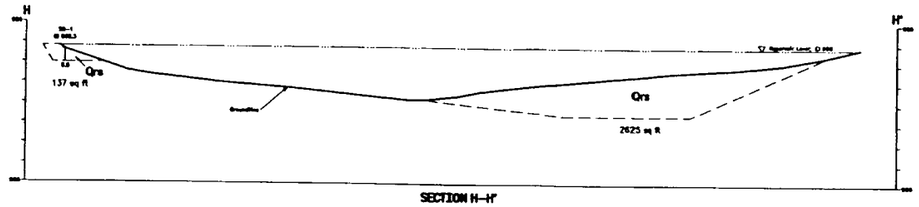


SECTION G–G'



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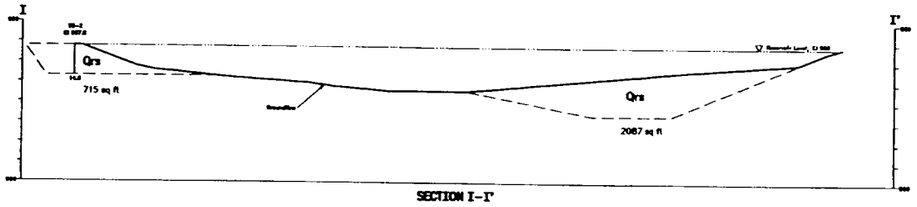
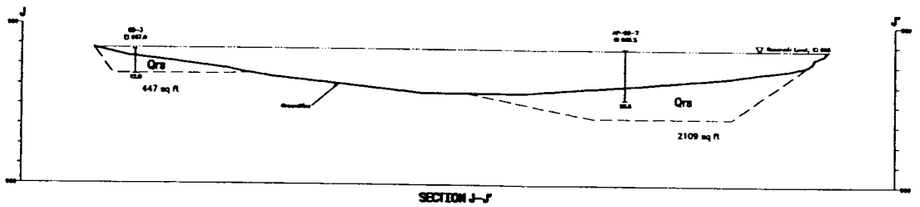
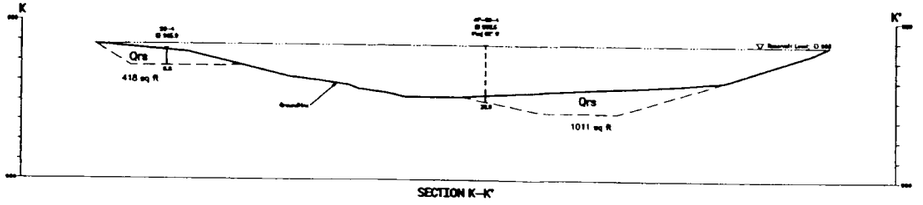


SECTION I–I'



SECTION J–J'



SECTION K–K'

Notes:

1. Refer to dwg 448–100–16 for General Geologic Explanation, Legend and Notes.
2. Refer to dwg 448–100–17 for locations of cross sections and explorations.
3. Dashed groundline is based on data from 1972 contours.

40 0 40 80 120
SCALE OF FEET

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BUREAU OF RECLAMATION
ROGUE RIVER BASIN PROJECT – OREGON

SAVAGE RAPIDS DAM
SEDIMENTATION STUDY
GEOLOGIC SECTIONS A–A' THROUGH K–K'

GEOLOGY R.J. INK
DRAWN T. ENGLAND
TECH APPROVAL
CHECKED
APPROVED
PROGRAM MANAGER

CADD SYSTEM AutoCAD v14
CADD FILE NAME (average square) 448-18
DATE PLOTTED 4-11-00
BOISE, IDAHO NOVEMBER 1999
SHEET 1 OF 1

448–100–18

Attachment B

GEOLOGIC LOGS OF DRILL HOLES

SUMMARY OF TEST DRILLING

FEATURE Savage Rapids Dam **PROJECT** Rogue River Basin **STATE** Oregon

Hole Number	Location	Coordinates		Collar Elev.	Depth of Hole	Date Completed	Depth of Water Date Measured	Remarks
		North	East					
AP-99-1		286,156	4,185,451	968.6	28.9'	9-23-99		
AP-99-2		286,187.3	4,185,491.8	968.6	35.7'	9-24-99		
AP-99-3		286,178	4,185,652	968.6	45.7'	9-25-99		
AP-99-4		286,281.5	4,185,966.5	968.8	26.5'	9-27-99		
AP-99-5		286,246.4	4,185,957.2	968.8	43.5'	9-27-99		
AP-99-6		286,360.3	4,186,378.2	968.5	36.9'	9-28-99		
AP-99-7		286,262.3	4,185,296.6	968.5	25.6'	9-29-99		
AP-99-8		286,388.3	4,184,943.8	968.5	31.6'	9-29-99		
AP-99-9		286,728.3	4,184,496.1	968.2	28.8'	9-30-99		
AP-99-10		286,592.5	4,184,704.9	968.2	27.8'	9-30-99		
AP-99-11		286,337.6	4,186,806.9	967.8	22.5'	10-1-99		
AP-99-12		286,224	4,185,663	968.7	43.1'	10-2-99		

Note: Horizontal coordinates are reported in the NAD 1983 datum; vertical coordinates are reported in the NAVD 1988 datum and are based on the reservoir gage located on the right side of the spillway crest near the pumping plant; the reservoir gage is referenced to the 1929 NGVD and elevations have been corrected to the 1988 NAVD using a conversion factor of +4.6 feet.

GEOLOGIC LOG OF DRILL HOLE NO. AP-99-1

SHEET 1 OF 1

FEATURE: Savage Rapids Dam
LOCATION: Reservoir
BEGUN: 9-23-99 FINISHED: 9-23-99
DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED:

PROJECT: Rogue River Basin
COORDINATES: N 286156 E 4185451
TOTAL DEPTH: 28.9
DEPTH TO BEDROCK: 28.9

STATE: Oregon
GROUND ELEVATION: 968.6
ANGLE FROM HORIZONTAL: 90 AZIMUTH:
HOLE LOGGED BY: R. Link
REVIEWED BY:

NOTES

PURPOSE OF HOLE
To determine the composition and volume of sediments stored behind Savage Rapids Dam.

DRILL EQUIPMENT
Ingersoll-Rand A200 skid-mounted drill.

DRILLER
Drill Foreman Kevin Herrmann.

DRILL SETUP
Set up on Savage Rapids Reservoir using custom-built floating drilling platform equipped with pontoons and 35-hp outboard motor.

DRILLING METHODS
Drilled with 10" O.D., 6.25" I.D. hollow-stem flight augers (AP). Took drive samples on approx. 2.5' intervals starting at top of river bed using 3.5" I.D. split-tube sample barrel fitted with basket catcher, 350-lbm safety hammer and cathead with rope.

DRILLING CONDITIONS
0.0-26.5': Set AP through reservoir water.
26.5-28.9': Slow and rough; sampler appeared to bounce on bedrock surface. AP under heavy torque, springing free when loosening drill head for sampling; drill string sank to reservoir bottom. Retrieved string with aid of dive team.

CASING RECORD

1999 Date	AP Sz	Depth Hole	Depth AP
9-23	6"	28.9	28.9

FLUID RETURN AND COLOR
No fluid used.

WATER LEVEL DURING DRILLING
Water level stayed at reservoir surface, i.e., 0.0'.

HOLE COMPLETION
Retrieved AP from reservoir bottom, reversing auger rotation to move cuttings back down hole.

DEPTH	TYPE OF HOLE	% CORE RECOVERY	VISUAL CLASS	LAB CLASS	FLO CLASS/LITH / ELEVATION	CLASSIFICATION AND PHYSICAL CONDITION
5						The measuring point for this drill hole was the reservoir water surface; all depths reported on this log correspond to the same measurements reported by the driller.
						0.0-26.5': WATER.
10						26.5-28.9': RESERVOIR SEDIMENTS (Qrs).
					Water	Poor recovery. Sample composed of gravel and cobble; insufficient sample mass to perform a soil classification. Recovered sample consists of about 50% fine to coarse, hard, subangular to subrounded gravel; about 50% fine, hard, subangular cobble (single particle); trace of fine to medium, hard, subangular to subrounded sand, trace of nonplastic fines; maximum dimension, 100 mm; wet, dark gray; heterogeneous, dimensions of cobble are 90 by 60 by 100 mm; sand and fines occur as thin, dark brown coatings on larger particles; particle composition is chiefly basalt and metavolcanics with minor quartz; no reaction with HCl. NOTE: Sample interval may be exaggerated as sampler appeared to bounce along sloping bedrock surface while driving with 350-lbm hammer.
15						
20						
25					942.1	
	DS	13	n/a	n/a	Qrs	28.9': BOTTOM OF HOLE. Underwater examination of site showed bedrock outcrops of strongly cemented conglomerate overlain by thin veneer of reservoir sediments; particles could not be dislodged from cemented matrix with heavy hammer blows.
30		BOTTOM OF HOLE			939.7	

NOTES:
1. Geologic descriptors are defined in the Engineering Geology Field Manual, Second Edition, Volume 1 (U.S. Bureau of Reclamation, 1998).

2. Samples were logged in the field using Designation USBR 5005-86, "Procedure for Determining Unified Soil Classification (Visual Method)"; laboratory classifications have been prepared using Designation USBR 5000-86, "Procedure for Determining Unified Soil Classification (Laboratory Method)".

COMMENTS:

AP = 10" O.D., 6.25" I.D. hollow-stem flight augers
DS = Drive Sample
Cs = Casing
Sz = Size of Casing
I.D. = Inside Diameter
O.D. = Outside Diameter
Cu = Coefficient of Uniformity
Cc = Coefficient of Curvature
SpG = Specific Gravity (minus #4 fraction)
n/a = Not available; insufficient sample mass to perform soil classification.

GEOLOGIC LOG OF DRILL HOLE NO. AP-99-2

FEATURE: Savage Rapids Dam
LOCATION: Reservoir
BEGUN: 9-24-99 FINISHED: 9-24-99
DEPTH AND ELEV OF WATER LEVEL AND DATE MEASURED:

PROJECT: Rogue River Basin
COORDINATES: N 286187.3 E 4185491.8
TOTAL DEPTH: 35.7
DEPTH TO BEDROCK:

STATE: Oregon
GROUND ELEVATION: 968.6
ANGLE FROM HORIZONTAL: 90 AZIMUTH:
HOLE LOGGED BY: R. Link
REVIEWED BY:

NOTES

PURPOSE OF HOLE
To determine the composition and volume of sediments stored behind Savage Rapids Dam.

DRILL EQUIPMENT
Ingersoll-Rand A200 skid-mounted drill.

DRILLER
Drill Foreman Kevin Herrmann.

DRILL SETUP
Set up on Savage Rapids Reservoir using custom-built floating drilling platform equipped with pontoons and 35-hp outboard motor.

DRILLING METHODS
Drilled with 10" O.D., 6.25" I.D. hollow-stem flight augers (AP). Took drive samples on approx. continuous intervals starting at top of lake bed using 3.5" I.D. split-tube sample barrel fitted with basket catcher, 350-lbm safety hammer and cathead with rope.

SAMPLE INTERVALS
25.0-27.0' 3.75" OS
27.0-29.0' 3.75" OS
29.0-31.0' 3.75" OS
" 3" OS
33.7-35.7' 3.75" OS

DRILLING CONDITIONS
0.0-25.0': Set AP through reservoir water.
25.0-29.0': Slow and soft with rough areas. No recovery in sample from 26.9-29.0'; tripped back in with smaller 3" I.D. barrel equipped with flapper valve; no recovery in second attempt.
29.0-35.7': Slow and rough; drilling platform whipping back and forth; hole at or very near limit of drilling equipment. About 1.0' of slough in hole after cleanout run to 33.7'; inserted chopping bit and flushed slough from hole. No recovery in sample interval from 33.7-35.7'; fingers of basket catcher for barrel were too widely spaced to retain sample.

CASING RECORD

1999 Date	AP Sz	Depth Hole	Depth AP
9-24	6"	35.7	33.7

DEPTH	TYPE OF HOLE	% CORE RECOVERY	% MINUS #230	VISUAL CLASS	LAB CLASS	FLD CLASS/LITH / ELEVATION
5						
10						
15						Water
20						
25						943.6
	DS	40	0.07	(GP) sc	(GP) s	
	DS	0		NoRec	NoRec	
30	DS	10		n/a	n/a	Qrs
	AP					
35	DS	0		NoRec	NoRec	932.9
				BOTTOM OF HOLE		
40						

CLASSIFICATION AND PHYSICAL CONDITION

The measuring point for this drill hole was the reservoir water surface; all depths reported on this log correspond to the same measurements reported by the driller.

0.0-25.0': WATER.

25.0-35.7': RESERVOIR SEDIMENTS (Qrs).

25.0-27.0': POORLY GRADED GRAVEL WITH SAND AND COBBLES (GP)sc. About 65% fine to coarse, hard, subangular to rounded gravel; about 35% fine to coarse, hard, angular to subrounded sand; about 5% nonplastic fines; includes single cobble measuring 110 by 100 by 80 mm (comprises about 50% of the sample by volume); maximum dimension, 110 mm; wet, dark gray to dark brown; includes fine, oxidized organic debris; heterogeneous, loose; no reaction with HCl. LAB TEST DATA: 50% gravel, 48% sand, 2% fines; Cu = 27.78, Cc = 0.14; SpG = 2.703; laboratory classification of sample is POORLY GRADED GRAVEL WITH SAND (GP)s.

27.0-29.0': No recovery. Second sample attempt in this interval using flapper valve also had no recovery. Residue on flapper valve consisted entirely of fine to medium sand with minor silt.

29.0-31.0': Poor recovery. Sample composed of gravel and sand; insufficient sample mass to perform a soil classification. Recovered sample consists of about 85% fine to coarse, hard, subangular to subrounded gravel; about 15% fine to coarse, hard, angular to subrounded sand; trace of nonplastic fines; maximum dimension, 70 mm; wet, dark gray; heterogeneous; particle composition is chiefly basalt and metavolcanics with minor quartz; no reaction with HCl.

33.7-35.7': No recovery. Sample recovery limited to several fine gravel and sand particles lodged in the basket catcher of the sampler.

35.7': BOTTOM OF HOLE. Hole drilling very hard and rough; at or very near the limit of the drilling equipment.

COMMENTS:

AP = 10" O.D., 6.25" I.D. hollow-stem flight augers
DS = Drive Sample — NoRec = No Recovery
Cs = Casing — Sz = Size of Casing
I.D. = Inside Diameter — O.D. = Outside Diameter
Cu = Coefficient of Uniformity — Cc = Coefficient of Curvature
SpG = Specific Gravity (minus #4 fraction)
n/a = not available; insufficient sample mass to perform soil classification

GEOLOGIC LOG OF DRILL HOLE NO. AP-99-2

FEATURE: Savage Rapids Dam
LOCATION: Reservoir
BEGUN: 9-24-99 FINISHED: 9-24-99
DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED:

PROJECT: Rogue River Basin
COORDINATES: N 286187.3 E 4185491.8
TOTAL DEPTH: 35.7
DEPTH TO BEDROCK:

STATE: Oregon
GROUND ELEVATION: 968.6
ANGLE FROM HORIZONTAL: 90 AZIMUTH:
HOLE LOGGED BY: R. Link
REVIEWED BY:

NOTES	CLASSIFICATION AND PHYSICAL CONDITION (CONTINUED)	
FLUID RETURN AND COLOR No fluid used. WATER LEVEL DURING DRILLING Water level stayed at reservoir surface, i.e., 0.0'. HOLE COMPLETION Retrieved AP from reservoir bottom, reversing auger rotation to move cuttings back down hole.	NOTES: 1. Geologic descriptors are defined in the Engineering Geology Field Manual, Second Edition, Volume 1 (U.S. Bureau of Reclamation, 1998). 2. Samples were logged in the field using Designation USBR 5005-86, "Procedure for Determining Unified Soil Classification (Visual Method)"; laboratory classifications have been prepared using Designation USBR 5000-86, "Procedure for Determining Unified Soil Classification (Laboratory Method)".	

GEOLOGIC LOG OF DRILL HOLE NO. AP-99-3

FEATURE: Savage Rapids Dam
LOCATION: Reservoir
BEGUN: 9-25-99 FINISHED: 9-25-99
DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED:

PROJECT: Rogue River Basin
COORDINATES: N 286178 E 4185652
TOTAL DEPTH: 45.7
DEPTH TO BEDROCK:

STATE: Oregon
GROUND ELEVATION: 968.6
ANGLE FROM HORIZONTAL: 90 AZIMUTH:
HOLE LOGGED BY: A. Link
REVIEWED BY:

NOTES

PURPOSE OF HOLE
To determine the composition and volume of sediments stored behind Savage Rapids Dam.

DRILL EQUIPMENT
Ingersoll-Rand A200 skid-mounted drill.

DRILLER
Drill Foreman Kevin Herrmann.

DRILL SETUP
Set up on Savage Rapids Reservoir using custom-built floating drilling platform equipped with pontoons and 35-hp outboard motor.

DRILLING METHODS
Drilled with 10" O.D., 6.25" I.D. hollow-stem flight augers (AP). Took drive samples on approx. continuous intervals starting at top of lake bed using 3" I.D. split-tube sample barrel sprayed with PAM aerosol vegetable coating and fitted with basket catcher and plastic baffle, 140-lbm safety hammer and cathead with rope. Sampler allowed to set on hole bottom for 10 minutes before retrieval.

SAMPLE INTERVALS
26.8-28.8' 3" DS
30.2-32.2' 3" DS
32.5-34.5' 3" DS
35.3-37.3' 3" DS
37.8-39.8' 3" DS
41.7-43.7' 3" DS

DRILLING CONDITIONS
0.0-26.8': Set AP through reservoir water.
26.8-32.5': Slow and very rough. Drilling platform twisting back and forth while augering; hole going crooked at 30', pulled back on augers to straighten out hole.
32.5-37.8': Fast and smooth with rough areas from 35.3-37.8'.
37.8-45.7': Slow and rough; platform rocking about and augers jamming during drilling; repeatedly reverse auger rotation to clear jams. Augers refused at 45.7'.

CASING RECORD

1999 Date	AP Sz	Depth Hole	Depth AP
9-25	6"	45.7	45.7

DEPTH	TYPE OF HOLE	% CORE RECOVERY	% MINUS #230	VISUAL CLASS	LAB CLASS	FLD CLASS/LITH / ELEVATION
						Water
						941.8
	DS	25	0.1	(GP) s	(SP) g	
	AP					
	DS	65	0.3	(SP) g	SP	
	DS	50	0.2	SP	SP	
	AP					
	DS	55	0.03	SP	(SP) g	Qrs
	AP					
	DS	55	0.03	(SP) g	SP	
	AP					
	DS	45	1.1	(SP) g	SP	
	AP					
			BOTTOM OF HOLE			922.9

CLASSIFICATION AND PHYSICAL CONDITION

The measuring point for this drill hole was the reservoir water surface; all depths reported on this log correspond to the same measurements reported by the driller.

0.0-26.8': WATER.

26.8-45.7': RESERVOIR SEDIMENTS (Qrs).

26.8-28.8': POORLY GRADED GRAVEL WITH SAND (GP) s. About 80% fine to coarse, hard, subangular to rounded gravel; about 20% fine to coarse, hard, angular to subrounded sand; trace of fines; maximum size, 60 mm; wet, dark gray; includes minor fine, oxidized organic debris with scattered fresh roots; heterogeneous, loose; particle composition consists of basalt and metavolcanics with minor quartz; no reaction with HCl.
LAB TEST DATA: 76% sand, 22% gravel, 2% fines; Cu = 3.13, Cc = 0.75; SpG = 2.703; laboratory classification of sample is POORLY GRADED SAND WITH GRAVEL (SP) g.

30.2-32.2': POORLY GRADED SAND WITH GRAVEL (SP) g. About 85% fine to coarse, hard, angular to subrounded sand; about 15% predominantly fine, hard, subangular to subrounded gravel; trace of fines; maximum size, 35 mm; wet, dark gray speckled white; heterogeneous, loose; particle composition consists of basalt, metavolcanics, quartz, mica and feldspar; no reaction with HCl.
LAB TEST DATA: 93% sand, 6% gravel, 1% fines; Cu = 3.44, Cc = 1.02; SpG = 2.707; laboratory classification of sample is POORLY GRADED SAND (SP).

32.5-34.5': POORLY GRADED SAND (SP). About 90% fine to coarse, hard angular to subrounded sand; about 10% fine to coarse, hard, subangular to rounded gravel; trace of fines; maximum size, 45 mm; wet, dark gray to dark brown; includes fine, oxidized organic debris; heterogeneous, loose; particle composition consists of basalt, metavolcanics and quartz; no reaction with HCl.
LAB TEST DATA: 92% sand, 5% gravel, 3% fines; Cu = 4.05, Cc = 0.99; SpG

COMMENTS:

AP = 10" O.D., 6.25" I.D. hollow-stem flight augers.
DS = Drive Sample
Cs = Casing
Sz = Size of Casing
I.D. = Inside Diameter
O.D. = Outside Diameter
Cu = Coefficient of Uniformity
Cc = Coefficient of Curvature
SpG = Specific Gravity (minus #4 fraction)

GEOLOGIC LOG OF DRILL HOLE NO. AP-99-3

FEATURE: Savage Rapids Dam
LOCATION: Reservoir
BEGUN: 9-25-99 FINISHED: 9-25-99
DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED:

PROJECT: Rogue River Basin
COORDINATES: N 286178 E 4185652
TOTAL DEPTH: 45.7
DEPTH TO BEDROCK:

STATE: Oregon
GROUND ELEVATION: 968.6
ANGLE FROM HORIZONTAL: 90 AZIMUTH:
HOLE LOGGED BY: R. Link
REVIEWED BY:

NOTES

FLUID RETURN AND COLOR
No fluid used.

WATER LEVEL DURING DRILLING
Water level stayed at reservoir surface, i.e., 0.0'.

HOLE COMPLETION
Retrieved AP from reservoir bottom, reversing auger rotation to move cuttings back down hole.

CLASSIFICATION AND PHYSICAL CONDITION (CONTINUED)

= 2.723.

35.3-37.3': POORLY GRADED SAND (SP). About 90% fine to coarse, hard, angular to rounded sand; about 10% predominantly fine, hard, subangular to rounded gravel; trace of fines; maximum size, 20 mm; wet, dark gray; includes fine, oxidized organic debris; heterogeneous, loose; particle composition consists of basalt, metavolcanics and quartz; no reaction with HCl.
LAB TEST DATA: 69% sand, 29% gravel, 2% fines; Cu = 8.21, Cc = 0.80; SpG = 2.750; laboratory classification of sample is POORLY GRADED SAND WITH GRAVEL (SP)g.

37.8-39.8': POORLY GRADED SAND WITH GRAVEL (SP)g. About 85% fine to coarse, hard, angular to rounded sand; about 15% fine to coarse, hard, angular to rounded gravel; trace of fines; maximum size, 45 mm; wet, dark gray; includes fine, oxidized organic debris; heterogeneous, loose, gravel particles concentrated in bottom 0.4' of sample, no evidence of obvious bedding plane at that point; particle composition consists of basalt, metavolcanics, quartz and agate; no reaction with HCl.
LAB TEST DATA: 88% sand, 10% gravel, 2% fines; Cu = 4.67, Cc = 0.60; SpG = 2.740; laboratory classification of sample is POORLY GRADED SAND (SP).

41.7-43.7': POORLY GRADED SAND WITH GRAVEL (SP)g. About 80% fine to coarse, hard, angular to rounded sand; about 15% predominantly fine, hard, subangular to rounded gravel; about 5% nonplastic fines; maximum size, 30 mm; wet, dark gray; includes fine, oxidized organic debris; heterogeneous, loose; particle composition consists of basalt, metavolcanics and quartz; no reaction with HCl.
LAB TEST DATA: 91% sand, 8% gravel, 1% fines; Cu = 5.56, Cc = 1.28; SpG = 2.738; laboratory classification of sample is POORLY GRADED SAND (SP).

45.7': BOTTOM OF HOLE. Hole drilling very hard and rough from 39.8 to 45.7'; augers refused at 45.7'.

NOTES:
1. Geologic descriptors are defined in the Engineering Geology Field Manual, Second Edition, Volume 1 (U.S. Bureau of Reclamation, 1998).

2. Samples were logged in the field using Designation USBR 5005-86, "Procedure for Determining Unified Soil Classification (Visual Method)"; laboratory classifications have been prepared using Designation USBR 5000-86, "Procedure for Determining Unified Soil

CLASSIFICATION AND PHYSICAL CONDITION (CONTINUED)

Classification (Laboratory Method)".

GEOLOGIC LOG OF DRILL HOLE NO. AP-99-4

SHEET 1 OF 1

FEATURE: Savage Rapids Dam
LOCATION: Reservoir
BEGUN: 9-27-99 FINISHED: 9-27-99
DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED:

PROJECT: Rogue River Basin
COORDINATES: N 286281.5 E 4185966.5
TOTAL DEPTH: 26.5
DEPTH TO BEDROCK:

STATE: Oregon
GROUND ELEVATION: 968.8
ANGLE FROM HORIZONTAL: 90 AZIMUTH:
HOLE LOGGED BY: R. Link
REVIEWED BY:

NOTES

PURPOSE OF HOLE
To determine the composition and volume of sediments stored behind Savage Rapids Dam.

DRILL EQUIPMENT
Ingersoll-Rand A200 skid-mounted drill.

DRILLER
Drill Foreman Kevin Herrmann.

DRILL SETUP
Set up on Savage Rapids Reservoir using custom-built floating drilling platform equipped with pontoons and 35-hp outboard motor.

DRILLING METHODS
Drilled with 10" O.D., 6.25" I.D. hollow-stem flight augers (AP). Took drive samples on approx. continuous intervals starting at top of lake bed using 3" I.D. split-tube sample barrel sprayed with PAM aerosol vegetable coating and fitted with basket catcher and plastic baffle, 140-lbm safety hammer and cathead with rope. Sampler allowed to set on hole bottom for 10 minutes before retrieval.

SAMPLE INTERVALS
24.6-26.2' 3" DS

DRILLING CONDITIONS
0.0-24.6': Set AP through reservoir water.
24.6-26.5': Slow and very rough. Drilling platform twisting back and forth while augering. Augers refused at 26.5'; moved drilling platform to center of reservoir and started a new hole.

CASING RECORD

1999 Date	AP Sz	Depth Hole	Depth AP
9-27	6"	26.5	26.5

FLUID RETURN AND COLOR
No fluid used.

WATER LEVEL DURING DRILLING
Water level stayed at reservoir surface, i.e., 0.0'.

HOLE COMPLETION
Retrieved AP from reservoir bottom, reversing auger rotation to move cuttings back down hole.

DEPTH	TYPE OF HOLE	% CORE RECOVERY	VISUAL CLASS	LAB CLASS	FLD CLASS/LITH	ELEVATION
5						
10					Water	
15						
20						
25	DS	0	NoRec	NoRec	Grs	944.2
	BOTTOM OF HOLE					942.3
30						

CLASSIFICATION AND PHYSICAL CONDITION

The measuring point for this drill hole was the reservoir water surface; all depths reported on this log correspond to the same measurements reported by the driller.

0.0-24.6': WATER.

24.6-26.5': RESERVOIR SEDIMENTS (Grs).

24.6-26.2': No recovery. Lake bottom felt soft when setting drill string for sampling.

26.5': BOTTOM OF HOLE. Augers refused at 26.5' in cleanout run following drive sample. Hole may have intercepted block of riprap slope protection observed along right shoreline of reservoir at this location.

NOTES:
1. Geologic descriptors are defined in the Engineering Geology Field Manual, Second Edition, Volume 1 (U.S. Bureau of Reclamation, 1998).

2. Samples were logged in the field using Designation USBR 5005-86, "Procedure for Determining Unified Soil Classification (Visual Method)"; laboratory classifications have been prepared using Designation USBR 5000-86, "Procedure for Determining Unified Soil Classification (Laboratory Method)".

COMMENTS:

AP = 10" O.D., 6.25" I.D. hollow-stem flight augers
DS = Drive Sample
NoRec = No Recovery
Cs = Casing
Sz = Size of Casing
I.D. = Inside Diameter
O.D. = Outside Diameter
Cu = Coefficient of Uniformity
Cc = Coefficient of Curvature
SpG = Specific Gravity (minus #4 fraction)

GEOLOGIC LOG OF DRILL HOLE NO. AP-99-5

FEATURE: Savage Rapids Dam
LOCATION: Reservoir
BEGUN: 9-27-99 FINISHED: 9-27-99
DEPTH AND ELEV OF WATER LEVEL AND DATE MEASURED:

PROJECT: Rogue River Basin
COORDINATES: N 286246.4 E 4185957.2
TOTAL DEPTH: 43.5
DEPTH TO BEDROCK:

STATE: Oregon
GROUND ELEVATION: 968.8
ANGLE FROM HORIZONTAL: 90 AZIMUTH:
HOLE LOGGED BY: R. Link
REVIEWED BY:

NOTES

PURPOSE OF HOLE
To determine the composition and volume of sediments stored behind Savage Rapids Dam.

DRILL EQUIPMENT
Ingersoll-Rand A200 skid-mounted drill.

DRILLER
Drill Foreman Kevin Herrmann.

DRILL SETUP
Set up on Savage Rapids Reservoir using custom-built floating drilling platform equipped with pontoons and 35-hp outboard motor.

DRILLING METHODS
Drilled with 10" O.D., 6.25" I.D. hollow-stem flight augers (AP). Took drive samples on approx. 2-foot intervals starting at top of lake bed using 3" I.D. split-tube sample barrel sprayed with PAM aerosol vegetable coating and fitted with basket catcher and plastic baffle, 140-lbm safety hammer and cathead with rope. Sampler allowed to set on hole bottom for 10 minutes before retrieval.

SAMPLE INTERVALS
23.0-25.8' 3" DS
26.6-28.6' 3" DS
31.4-33.4' 3" DS
35.8-37.8' 3" DS
39.9-41.9' 3" DS

DRILLING CONDITIONS
0.0-23.0': Set AP through reservoir water.
23.0-26.6': Fast and smooth.
26.6-40.4': Slow and smooth with rough areas.
40.4-43.5': Slow and very rough; drilled extremely hard from 42.5-43.5'. Augers refused at 43.5'.

CASING RECORD

1999 Date	AP Sz	Depth Hole	Depth AP
9-27	6"	43.5	43.5

FLUID RETURN AND COLOR
No fluid used.

WATER LEVEL DURING DRILLING
Water level stayed at reservoir surface, i.e., 0.0'.

HOLE COMPLETION
Retrieved AP from

DEPTH	TYPE OF HOLE	% CORE RECOVERY	% MINUS #230	VISUAL CLASS	LAB CLASS	FLD CLASS/LITH / ELEVATION
5						
10						Water
15						
20						
						945.8
25	DS	0		NoRec	NoRec	
	AP					
	DS	40	<0.06	SP	(SP) g	
30	AP					
	DS	45	0.08	(GP) s	(GP) s	Qrs
35	AP					
	DS	30	0.4	(SP) g	(SP) g	
	AP					
40	DS	0		NoRec	NoRec	
	AP					
						925.3
45			BOTTOM OF HOLE			

CLASSIFICATION AND PHYSICAL CONDITION

The measuring point for this drill hole was the reservoir water surface; all depths reported on this log correspond to the same measurements reported by the driller.

0.0-23.0': WATER.

23.0-43.5': RESERVOIR SEDIMENTS (Qrs).

23.0-25.8': No recovery. Lake bottom felt soft when setting drill string for sample interval; overdrove sampler additional 0.8' to improve recovery with no success.

26.6-28.6': POORLY GRADED SAND (SP). About 90% fine to coarse, hard, angular to subrounded sand; about 10% predominantly fine, hard, subangular to subrounded gravel; trace of fines; maximum size, 40 mm; wet, dark gray speckled white; includes fine, oxidized organic debris; heterogeneous, loose; particle composition consists of basalt, metavolcanics and quartz; no reaction with HCl.
LAB TEST DATA: 84% sand, 15% gravel, 1% fines; Cu = 4.00, Cc = 0.79; SpG = 2.695; laboratory classification of sample is POORLY GRADED SAND WITH GRAVEL (SP)g.

31.4-33.4': POORLY GRADED GRAVEL WITH SAND (GP)s. About 55% fine to coarse, hard, angular to subrounded gravel; about 45% fine to coarse, hard, subangular to subrounded sand; trace of fines; maximum size, 60 mm; wet, dark gray; heterogeneous, loose to dense; particle composition consists of basalt, metavolcanics and quartz; no reaction with HCl.
LAB TEST DATA: 51% gravel, 49% sand, 0% fines; Cu = 5.00, Cc = 0.56; SpG = 2.742.

35.8-37.8': POORLY GRADED SAND WITH GRAVEL (SP)g. About 85% predominantly medium to coarse, hard, angular to subrounded sand; about 15% fine to coarse, hard, subangular to rounded gravel; trace of fines; maximum size, 30 mm; wet, dark gray; includes fine, oxidized organic debris; stratified, top 0.3' of sample consists of about 95% predominantly fine sand with about 5% fines, loose to dense; particle

COMMENTS:

AP = 10" O.D., 6.25" I.D. hollow-stem flight augers.
DS = Drive Sample — NoRec = No recovery
Cs = Casing — Sz = Size of Casing
I.D. = Inside Diameter — O.D. = Outside Diameter
Cu = Coefficient of Uniformity — Cc = Coefficient of Curvature
SpG = Specific Gravity (minus #4 fraction)

GEOLOGIC LOG OF DRILL HOLE NO. AP-99-5

FEATURE: Savage Rapids Dam
LOCATION: Reservoir
BEGUN: 9-27-99 FINISHED: 9-27-99
DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED:

PROJECT: Rogue River Basin
COORDINATES: N 286246.4 E 4185957.2
TOTAL DEPTH: 43.5
DEPTH TO BEDROCK:

STATE: Oregon
GROUND ELEVATION: 968.8
ANGLE FROM HORIZONTAL: 90 AZIMUTH:
HOLE LOGGED BY: A. Link
REVIEWED BY:

NOTES	CLASSIFICATION AND PHYSICAL CONDITION (CONTINUED)	
reservoir bottom, reversing auger rotation to move cuttings back down hole.	composition consists of basalt, metavolcanics, quartz and mica; no reaction with HCl. LAB TEST DATA: 75% sand, 21% gravel, 4% fines; Cu = 7.38, Cc = 0.51; SpG = 2.727. 39.9-41.9': No recovery. Sampler drove very easily; residue trapped behind basket catcher consisted of medium to coarse sand and fine gravel, similar to bottom half of previous sample. 43.5': BOTTOM OF HOLE. Hole drilling very hard and rough from 42.5 to 43.5'; augers refused at 43.5'. NOTES: 1. Geologic descriptors are defined in the Engineering Geology Field Manual, Second Edition, Volume 1 (U.S. Bureau of Reclamation, 1998). 2. Samples were logged in the field using Designation USBR 5005-86, "Procedure for Determining Unified Soil Classification (Visual Method)"; laboratory classifications have been prepared using Designation USBR 5000-86, "Procedure for Determining Unified Soil Classsification (Laboratory Method)".	

GEOLOGIC LOG OF DRILL HOLE NO. AP-99-6

FEATURE: Savage Rapids Dam
LOCATION: Reservoir
BEGUN: 9-28-99 FINISHED: 9-28-99
DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED:

PROJECT: Rogue River Basin
COORDINATES: N 286360.3 E 4186378.2
TOTAL DEPTH: 36.9
DEPTH TO BEDROCK:

STATE: Oregon
GROUND ELEVATION: 968.5
ANGLE FROM HORIZONTAL: 90 AZIMUTH:
HOLE LOGGED BY: R. Link
REVIEWED BY:

NOTES

PURPOSE OF HOLE
To determine the composition and volume of sediments stored behind Savage Rapids Dam.

DRILL EQUIPMENT
Ingersoll-Rand A200 skid-mounted drill.

DRILLER
Drill Foreman Kevin Herrmann.

DRILL SETUP
Set up on Savage Rapids Reservoir using custom-built floating drilling platform equipped with pontoons and 35-hp outboard motor.

DRILLING METHODS
Drilled with 10" O.D., 6.25" I.D. hollow-stem flight augers (AP). Took drive samples on approx. 3-foot intervals starting at top of lake bed using 3" I.D. split-tube sample barrel sprayed with PAM aerosol vegetable coating and fitted with basket catcher and plastic baffle. 140-lbm safety hammer and cathead with rope. Sampler allowed to set on hole bottom for 10 minutes before retrieval.

SAMPLE INTERVALS

18.0-20.2'	3"	DS
21.7-23.7'	3"	DS
25.9-27.9'	3"	DS
31.1-33.1'	3"	DS
36.0-36.9'	3"	DS

DRILLING CONDITIONS
0.0-18.0': Set AP through reservoir water.
18.0-25.9': Slow and smooth; rougher from 20.7-21.7'.
25.9-35.7': Slow and rough.
35.7-36.9': Slow and very rough; drilled very hard with drill at or very near limit of equipment. DS rebounding with no penetration at 36.9'.

CASING RECORD

1999 Date	AP Sz	Depth Hole	Depth AP
9-28	6"	36.9	36.0

FLUID RETURN AND COLOR
No fluid used.

WATER LEVEL DURING DRILLING
Water level stayed at reservoir surface, i.e., 0.0'.

DEPTH	TYPE OF HOLE	% CORE RECOVERY	% MINUS #230	VISUAL CLASS	LAB CLASS	FLD CLASS/LITH / ELEVATION
5						
10						Water
15						
						950.5
20	DS	11		n/a	n/a	
	AP					
	DS	55	0.1	(SP) g	(SP) g	
25	AP					
	DS	60	0.3	(SP) g	(SP) g	Qrs
30	AP					
	DS	45	0.1	(GP) s	(SP) g	
35	AP					
	DS	0		NoRec	NoRec	931.6
	BOTTOM OF HOLE					
40						

CLASSIFICATION AND PHYSICAL CONDITION

The measuring point for this drill hole was the reservoir water surface; all depths reported on this log correspond to the same measurements reported by the driller.

0.0-18.0': WATER.

18.0-36.9': RESERVOIR SEDIMENTS (Qrs).

18.0-20.2': Poor recovery. Sample composed of gravel and sand; insufficient sample mass to perform soil classification. Recovered sample consists of predominantly coarse, hard, angular to rounded gravel and predominantly medium to coarse, hard, angular to rounded sand; maximum size, 70 mm; wet, dark brown; heterogeneous, loose; particle composition consists of basalt, quartz and metavolcanics; no reaction with HCl.
NOTE: Sampler sank 0.2' under weight of drill rods at start of sample interval; drove sampler from 18.2-20.2' with safety hammer.

21.7-23.7': POORLY GRADED SAND WITH GRAVEL (SP)g. About 75% fine to coarse, hard, angular to subrounded sand; about 20% fine to coarse, hard, subangular to rounded gravel; about 5% nonplastic fines; maximum size, 25 mm; wet, dark gray to dark brown; includes fine, oxidized organic debris; homogeneous, loose to dense; particle composition consists of basalt, metavolcanics and quartz; no reaction with HCl.
LAB TEST DATA: 79% sand, 17% gravel, 4% fines; Cu = 3.55, Cc = 1.06; SpG = 2.666.

25.9-27.9': POORLY GRADED SAND WITH GRAVEL (SP)g. About 85% fine to coarse, hard, angular to rounded sand; about 15% fine to coarse, hard, subangular to rounded gravel; trace of fines; maximum size, 40 mm; wet, dark gray speckled white; includes fine, oxidized organic debris; heterogeneous, loose to dense; particle composition consists of basalt, metavolcanics and quartz; no reaction with HCl.
LAB TEST DATA: 67% sand, 32% gravel, 1% fines; Cu = 4.71, Cc = 0.73; SpG = 2.884.

COMMENTS:

AP = 10" O.D., 6.25" I.D. hollow-stem flight augers.
DS = Drive Sample
Cs = Casing
I.D. = Inside Diameter
Cu = Coefficient of Uniformity
SpG = Specific Gravity (minus #4 fraction)
n/a = Not available; insufficient sample mass to perform soil classification.
NoRec = No recovery
Sz = Size of Casing
O.D. = Outside Diameter
Cc = Coefficient of Curvature

GEOLOGIC LOG OF DRILL HOLE NO. AP-99-6

FEATURE: Savage Rapids Dam
LOCATION: Reservoir
BEGUN: 9-28-99 FINISHED: 9-28-99
DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED:

PROJECT: Rogue River Basin
COORDINATES: N 286360.3 E 4186378.2
TOTAL DEPTH: 36.9
DEPTH TO BEDROCK:

STATE: Oregon
GROUND ELEVATION: 968.5
ANGLE FROM HORIZONTAL: 90 AZIMUTH:
HOLE LOGGED BY: R. Link
REVIEWED BY:

NOTES	CLASSIFICATION AND PHYSICAL CONDITION (CONTINUED)	
HOLE COMPLETION Retrieved AP from reservoir bottom, reversing auger rotation to move cuttings back down hole.	31.1-33.1': POORLY GRADED GRAVEL WITH SAND (GP)s. About 60% fine to coarse, hard, subangular to rounded gravel; about 40% fine to coarse, hard, angular to rounded sand; trace of fines; maximum size, 40 mm; wet, dark gray; includes fine, oxidized organic debris; heterogeneous, loose to dense; particle composition consists of basalt, metavolcanics and quartz; no reaction with HCl. LAB TEST DATA: 61% sand, 37% gravel, 2% fines; Cu = 10.00, Cc = 0.86; SpG = 2.754; laboratory classification of sample is POORLY GRADED SAND WITH GRAVEL (SP)g. 36.0-36.9': No recovery. Sampler rebounding with no penetration at 36.9'. 36.9': BOTTOM OF HOLE. Hole drilling very hard and rough from 35.7-36.0'. NOTES: 1. Geologic descriptors are defined in the Engineering Geology Field Manual, Second Edition, Volume 1 (U.S. Bureau of Reclamation, 1998). 2. Samples were logged in the field using Designation USBR 5005-86, "Procedure for Determining Unified Soil Classification (Visual Method)"; laboratory classifications have been prepared using Designation USBR 5000-86, "Procedure for Determining Unified Soil Classification (Laboratory Method)".	

GEOLOGIC LOG OF DRILL HOLE NO. AP-99-7

FEATURE: Savage Rapids Dam
LOCATION: Reservoir
BEGUN: 9-29-99 FINISHED: 9-29-99
DEPTH AND ELEV OF WATER LEVEL AND DATE MEASURED:

PROJECT: Rogue River Basin
COORDINATES: N 286262.3 E 4185296.6
TOTAL DEPTH: 25.6
DEPTH TO BEDROCK:

STATE: Oregon
GROUND ELEVATION: 968.5
ANGLE FROM HORIZONTAL: 90 AZIMUTH:
HOLE LOGGED BY: R. Link
REVIEWED BY:

NOTES

PURPOSE OF HOLE
To determine the composition and volume of sediments stored behind Savage Rapids Dam.

DRILL EQUIPMENT
Ingersoll-Rand A200 skid-mounted drill.

DRILLER
Drill Foreman Kevin Herrmann.

DRILL SETUP
Set up on Savage Rapids Reservoir using custom-built floating drilling platform equipped with pontoons and 35-hp outboard motor.

DRILLING METHODS
Drilled with 10" O.D., 6.25" I.D. hollow-stem flight augers (AP). Took drive samples on approx. 2-foot intervals starting at top of lake bed using 3" I.D. split-tube sample barrel sprayed with PAM aerosol vegetable coating and fitted with basket catcher and plastic baffle. 140-lbm safety hammer and cathead with rope. Sampler allowed to set on hole bottom for 10 minutes before retrieval.

SAMPLE INTERVALS
18.3-20.8' 3" OS
22.6-24.6' 3" OS

DRILLING CONDITIONS
0.0-18.3': Set AP through reservoir water. Top of lake bed very soft, as determined with weighted line.
18.3-22.5': Slow and smooth.
22.6-25.6': Slow and very rough. Augers refused at 25.6'.

CASING RECORD

1999 Date	AP Sz	Depth Hole	Depth AP
9-29	6"	25.6	25.6

FLUID RETURN AND COLOR
No fluid used.

WATER LEVEL DURING DRILLING
Water level stayed at reservoir surface, i.e., 0.0'.

HOLE COMPLETION
Retrieved AP from reservoir bottom, reversing auger rotation to move cuttings back down hole.

DEPTH	TYPE OF HOLE	% CORE RECOVERY	% MINUS #230	VISUAL CLASS	LAB CLASS	FLD CLASS/LITH / ELEVATION
5						
10						Water
15						
						950.2
20	DS	16	0.02	(GP) s	(GP) s	
	AP					Qrs
	DS	45	0.01	(SP) g	(SP) g	
25	AP					942.9
			BOTTOM OF HOLE			
30						

CLASSIFICATION AND PHYSICAL CONDITION

The measuring point for this drill hole was the reservoir water surface; all depths reported on this log correspond to the same measurements reported by the driller.

0.0-18.3': WATER.

18.3-25.6': RESERVOIR SEDIMENTS (Qrs).

18.3-20.8': POORLY GRADED GRAVEL WITH SAND (GP)s. About 85% fine to coarse, hard, subangular to subrounded gravel; about 15% fine to coarse, hard, angular to rounded sand; trace of fines; maximum size, 70 mm; wet, dark gray; includes fine, oxidized organic debris; heterogeneous, loose; particle composition consists of basalt, metavolcanics and quartz; no reaction with HCl.
LAB TEST DATA: 56% gravel, 43% sand, 1% fines; Cu = 14.14, Cc = 0.52; SpG = 2.714.
NOTE: Sampler sank 0.3' under weight of drill rods at start of sample interval; drove sampler from 18.6-20.8' with safety hammer.

22.6-24.6': POORLY GRADED SAND WITH GRAVEL (SP)g. About 85% fine to coarse, hard, angular to subrounded sand; about 15% fine to coarse, hard, subangular to rounded gravel; trace of fines; maximum size, 40 mm; wet, dark gray; heterogeneous, loose; particle composition consists of basalt, metavolcanics, quartz and andesite; no reaction with HCl.
LAB TEST DATA: 72% sand, 27% gravel, 1% fines; Cu = 4.50, Cc = 0.75; SpG = 2.718.

25.6': BOTTOM OF HOLE. Hole drilling very hard and rough from 22.5-25.6'; augers refused at 25.6'.

NOTES:
1. Geologic descriptors are defined in the Engineering Geology Field Manual, Second Edition, Volume 1 (U.S. Bureau of Reclamation, 1998).

2. Samples were logged in the field using Designation USBR 5005-86, "Procedure for Determining Unified Soil Classification (Visual Method)"; laboratory classifications have been

COMMENTS:

AP = 10" O.D., 6.25" I.D. hollow-stem flight augers
DS = Drive Sample
Cs = Casing
Sz = Size of Casing
I.D. = Inside Diameter
O.D. = Outside Diameter
Cu = Coefficient of Uniformity
Cc = Coefficient of Curvature
SpG = Specific Gravity (minus #4 fraction)

GEOLOGIC LOG OF DRILL HOLE NO. AP-99-7

FEATURE: Savage Rapids Dam
LOCATION: Reservoir
BEGUN: 9-29-99 FINISHED: 9-29-99
DEPTH AND ELEV OF WATER LEVEL AND DATE MEASURED:

PROJECT: Rogue River Basin
COORDINATES: N 286252.3 E 4185296.6
TOTAL DEPTH: 25.6
DEPTH TO BEDROCK:

STATE: Oregon
GROUND ELEVATION: 968.5
ANGLE FROM HORIZONTAL: 90 AZIMUTH:
HOLE LOGGED BY: R. Link
REVIEWED BY:

CLASSIFICATION AND PHYSICAL CONDITION (CONTINUED)	
prepared using Designation USBR 5000-86, "Procedure for Determining Unified Soil Classification (Laboratory Method)".	

GEOLOGIC LOG OF DRILL HOLE NO. AP-99-8

FEATURE: Savage Rapids Dam
LOCATION: Reservoir
BEGUN: 9-29-99 FINISHED: 9-29-99
DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED:

PROJECT: Rogue River Basin
COORDINATES: N 286388.3 E 4184943.8
TOTAL DEPTH: 31.6
DEPTH TO BEDROCK:

STATE: Oregon
GROUND ELEVATION: 968.5
ANGLE FROM HORIZONTAL: 90 AZIMUTH:
HOLE LOGGED BY: R. Link
REVIEWED BY:

NOTES

PURPOSE OF HOLE
To determine the composition and volume of sediments stored behind Savage Rapids Dam.

DRILL EQUIPMENT
Ingersoll-Rand A200 skid-mounted drill.

DRILLER
Drill Foreman Kevin Herrmann.

DRILL SETUP
Set up on Savage Rapids Reservoir using custom-built floating drilling platform equipped with pontoons and 35-hp outboard motor.

DRILLING METHODS
Drilled with 10" O.D., 6.25" I.D. hollow-stem flight augers (AP). Took drive samples on approx. 3-foot intervals starting at top of lake bed using 3" I.D. split-tube sample barrel sprayed with PAM aerosol vegetable coating and fitted with basket catcher and plastic baffle, 140-lbm safety hammer and cathead with rope. Sampler allowed to set on hole bottom for 10 minutes before retrieval.

SAMPLE INTERVALS
17.5-20.0' 3" OS
22.0-24.0' 3" OS
25.9-27.9' 3" OS
29.9-31.6' 3" OS

DRILLING CONDITIONS
0.0-17.5': Set AP through reservoir water. Top of lake bed very soft, as determined with weighted line.
17.5-22.0': Slow and rough.
22.0-31.6': Slow and smooth with rough areas below 24.9'. Sampler rebounding with no penetration at 31.6'; augers refused at 30.9' during cleanout run.

CASING RECORD

1999 Date	AP Sz	Depth Hole	Depth AP
9-29	6"	31.6	30.9

FLUID RETURN AND COLOR
No fluid used.

WATER LEVEL DURING DRILLING
Water level stayed at reservoir surface, i.e., 0.0'.

HOLE COMPLETION

DEPTH	TYPE OF HOLE	% CORE RECOVERY	% MINUS #230	VISUAL CLASS	LAB CLASS	FLD CLASS/LITH / ELEVATION
5						
10						Water
15						
						951.0
20	OS	15		n/a	n/a	
	AP					
	OS	35	0.1	SP	(SP) g	
25	AP					Qrs
	OS	75	0.1	(SP) g	SP	
	AP					
30	OS	71	0.3	(GP) s	(SP) g	
						936.9
				BOTTOM OF HOLE		
35						

CLASSIFICATION AND PHYSICAL CONDITION

The measuring point for this drill hole was the reservoir water surface; all depths reported on this log correspond to the same measurements reported by the driller.

0.0-17.5': WATER.

17.5-31.6': RESERVOIR SEDIMENTS (Qrs).

17.5-20.0': Poor recovery. Sample composed of gravel and sand; insufficient sample mass to perform a soil classification. Recovered sample consists of about 95% fine to coarse, hard, subangular to rounded gravel; about 5% predominantly coarse, hard, angular to rounded sand; maximum size, 55 mm; wet, dark gray; heterogeneous, loose; particle composition consists of basalt, metavolcanics and minor quartz; no reaction with HCl.

22.0-24.0': POORLY GRADED SAND (SP). About 90% fine to coarse, hard, angular to subrounded sand; about 10% fine to coarse, hard, subangular to subrounded gravel; trace of fines; maximum size, 30 mm; wet, dark gray; includes minor, fine, oxidized organic debris; heterogeneous, loose; particle composition consists of basalt, metavolcanics and quartz; no reaction with HCl.
LAB TEST DATA: 78% sand, 21% gravel, 1% fines; Cu = 4.85, Cc = 0.78; SpG = 2.700; laboratory classification of sample is POORLY GRADED SAND WITH GRAVEL (SP)g.

25.9-27.9': POORLY GRADED SAND WITH GRAVEL (SP)g. About 75% fine to coarse, hard, angular to rounded sand; about 25% fine to coarse, hard, subangular to rounded gravel; trace of fines; maximum size, 60 mm; wet, dark gray; heterogeneous, loose to dense; particle composition consists of basalt, metavolcanics and quartz; no reaction with HCl.
LAB TEST DATA: 84% sand, 13% gravel, 3% fines; Cu = 4.05, Cc = 0.86; SpG = 2.685; laboratory classification of sample is POORLY GRADED SAND (SP).

29.9-31.6': POORLY GRADED GRAVEL WITH SAND (GP)s. About 55% fine to

COMMENTS:

AP = 10" O.D., 6.25" I.D. hollow-stem flight augers
OS = Drive Sample
Cs = Casing
Sz = Size of Casing
I.D. = Inside Diameter
O.D. = Outside Diameter
Cu = Coefficient of Uniformity
Cc = Coefficient of Curvature
SpG = Specific Gravity (minus #4 fraction)
n/a = Not available; insufficient sample mass to perform soil classification.

GEOLOGIC LOG OF DRILL HOLE NO. AP-99-8

FEATURE: Savage Rapids Dam
LOCATION: Reservoir
BEGUN: 9-29-99 FINISHED: 9-29-99
DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED:

PROJECT: Rogue River Basin
COORDINATES: N 286388.3 E 4184943.8
TOTAL DEPTH: 31.6
DEPTH TO BEDROCK:

STATE: Oregon
GROUND ELEVATION: 968.5
ANGLE FROM HORIZONTAL: 90 AZIMUTH:
HOLE LOGGED BY: R. Link
REVIEWED BY:

NOTES	CLASSIFICATION AND PHYSICAL CONDITION (CONTINUED)	
Retrieved AP from reservoir bottom, reversing auger rotation to move cuttings back down hole.	coarse, hard, subangular to subrounded gravel; about 40% fine to coarse, hard, angular to rounded sand; about 5% nonplastic fines; maximum size, 65 mm; wet, dark gray; includes fine, oxidized organic debris; stratified, top half of sample consists chiefly of fine to medium sand while bottom half consists of coarse sand and gravel, no obvious bedding planes noted in sample; particle composition consists of basalt, metavolcanics and quartz; no reaction with HCl. LAB TEST DATA: 74% sand, 22% gravel, 4% fines; Cu = 7.62, Cc = 0.84; SpG = 2.739; laboratory classification of sample is POORLY GRADED SAND WITH GRAVEL (SP)g. 31.6': BOTTOM OF HOLE. Hole drilling very hard and rough from 30.4-30.9'; sampler rebounding with no penetration at 31.6'; augers refused at 30.9' during cleanout run. NOTES: 1. Geologic descriptors are defined in the Engineering Geology Field Manual, Second Edition, Volume 1 (U.S. Bureau of Reclamation, 1998). 2. Samples were logged in the field using Designation USBR 5005-86, "Procedure for Determining Unified Soil Classification (Visual Method)"; laboratory classifications have been prepared using Designation USBR 5000-86, "Procedure for Determining Unified Soil Classification (Laboratory Method)".	

GEOLOGIC LOG OF DRILL HOLE NO. AP-99-9

FEATURE: Savage Rapids Dam
LOCATION: Reservoir
BEGUN: 9-30-99 FINISHED: 9-30-99
DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED:

PROJECT: Rogue River Basin
COORDINATES: N 286728.3 E 4184496.1
TOTAL DEPTH: 28.8
DEPTH TO BEDROCK:

STATE: Oregon
GROUND ELEVATION: 968.2
ANGLE FROM HORIZONTAL: 90 AZIMUTH:
HOLE LOGGED BY: A. Link
REVIEWED BY:

NOTES

PURPOSE OF HOLE
To determine the composition and volume of sediments stored behind Savage Rapids Dam.

DRILL EQUIPMENT
Ingersoll-Rand A200 skid-mounted drill.

DRILLER
Drill Foreman Kevin Herrmann.

DRILL SETUP
Set up on Savage Rapids Reservoir using custom-built floating drilling platform equipped with pontoons and 35-hp outboard motor.

DRILLING METHODS
Drilled with 10" O.D., 6.25" I.D. hollow-stem flight augers (AP). Took drive samples on approx. 2-foot intervals starting at top of lake bed using 3" I.D. split-tube sample barrel sprayed with PAM aerosol vegetable coating and fitted with basket catcher and plastic baffle, 140-lbm safety hammer and cathead with rope. Sampler allowed to set on hole bottom for 10 minutes before retrieval.

SAMPLE INTERVALS
21.0-23.0' 3" DS
24.7-26.7' 3" DS
28.1-28.4' 3" DS

DRILLING CONDITIONS
0.0-21.0': Set AP through reservoir water. Top of lake bed very soft, as determined with weighted line.
21.0-28.1': Slow and smooth.
28.1-28.8': Slow and rough. Sampler rebounding with no penetration at 28.4'; augers refused at 28.8' during cleanout run.

CASING RECORD

1999 Date	AP Sz	Depth Hole	Depth AP
9-30	6"	28.8	28.8

FLUID RETURN AND COLOR
No fluid used.

WATER LEVEL DURING DRILLING
Water level stayed at reservoir surface, i.e., 0.0'.

HOLE COMPLETION
Retrieved AP from reservoir bottom.

DEPTH	TYPE OF HOLE	% CORE RECOVERY	% MINUS #230	VISUAL CLASS	LAB CLASS	FLD CLASS/LITH / ELEVATION
5						
10						Water
15						
20						947.2
	DS	0		NoRec	NoRec	
	AP					
25	DS	55	0.1	(GP)s	(SW)g	Qrs
	AP					
						939.4
30				BOTTOM OF HOLE		

CLASSIFICATION AND PHYSICAL CONDITION

The measuring point for this drill hole was the reservoir water surface; all depths reported on this log correspond to the same measurements reported by the driller.

0.0-21.0': WATER.

21.0-28.8': RESERVOIR SEDIMENTS (Qrs).

21.0-23.0': No recovery. Sample recovery limited to gravel particle 40 mm in diameter lodged behind basket catcher of sample barrel.

24.7-26.7': POORLY GRADED GRAVEL WITH SAND (GP)s. About 60% fine to coarse, hard, subangular to subrounded gravel; about 40% fine to coarse, hard, angular to rounded sand; trace of fines; maximum size, 45 mm; wet, dark gray; includes minor, fine, oxidized organic debris; heterogeneous, loose; particle composition consists of basalt, metavolcanics, and quartz with minor granitics; no reaction with HCl.
LAB TEST DATA: 69% sand, 29% gravel, 2% fines; Cu = 7.86, Cc = 1.04; SpG = 2.715; laboratory classification of sample is WELL-GRADED SAND WITH GRAVEL (SW)g.

28.1-28.4': POORLY GRADED GRAVEL WITH SAND (GP)s. About 55% fine to coarse, hard, subangular to rounded gravel; about 45% fine to coarse, hard, subangular to rounded sand; trace of fines; maximum size, 40 mm; wet, dark gray; heterogeneous, loose; particle composition consists of basalt, metavolcanics and quartz; no reaction with HCl.
CENTER COLUMN DATA: Type of Hole = DS; % Core Recovery = 67%; Visual Class = (GP)s; Lab Class = none, sample was not submitted for lab testing.

28.8': BOTTOM OF HOLE. Hole drilling very hard and rough from 28.1-28.8'; sampler rebounding with no penetration at 28.4'; augers refused at 28.8' during cleanout run.

NOTES:
1. Geologic descriptors are defined in the Engineering Geology Field Manual.

COMMENTS:

AP = 10" O.D., 6.25" I.D. hollow-stem flight augers
DS = Drive Sample
NoRec = No recovery
Cs = Casing
Sz = Size of Casing
I.D. = Inside Diameter
O.D. = Outside Diameter
Cu = Coefficient of Uniformity
Cc = Coefficient of Curvature
SpG = Specific Gravity (minus #4 fraction)

GEOLOGIC LOG OF DRILL HOLE NO. AP-99-9

FEATURE: Savage Rapids Dam
LOCATION: Reservoir
BEGUN: 9-30-99 FINISHED: 9-30-99
DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED:

PROJECT: Rogue River Basin
COORDINATES: N 286728.3 E 4184496.1
TOTAL DEPTH: 28.8
DEPTH TO BEDROCK:

STATE: Oregon
GROUND ELEVATION: 968.2
ANGLE FROM HORIZONTAL: 90 AZIMUTH:
HOLE LOGGED BY: R. Link
REVIEWED BY:

NOTES	CLASSIFICATION AND PHYSICAL CONDITION (CONTINUED)	
reversing auger rotation to move cuttings back down hole.	Second Edition, Volume 1 (U.S. Bureau of Reclamation, 1998). 2. Samples were logged in the field using Designation USBR 5005-86, "Procedure for Determining Unified Soil Classification (Visual Method)"; laboratory classifications have been prepared using Designation USBR 5000-86, "Procedure for Determining Unified Soil Classification (Laboratory Method)".	

GEOLOGIC LOG OF DRILL HOLE NO. AP-99-10

FEATURE: Savage Rapids Dam
LOCATION: Reservoir
BEGUN: 9-30-99 FINISHED: 9-30-99
DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED:

PROJECT: Rogue River Basin
COORDINATES: N 286592.5 E 4184704.9
TOTAL DEPTH: 27.8
DEPTH TO BEDROCK:

STATE: Oregon
GROUND ELEVATION: 968.2
ANGLE FROM HORIZONTAL: 90 AZIMUTH:
HOLE LOGGED BY: R. Link
REVIEWED BY:

NOTES

PURPOSE OF HOLE
To determine the composition and volume of sediments stored behind Savage Rapids Dam.

DRILL EQUIPMENT
Ingersoll-Rand A200 skid-mounted drill.

DRILLER
Drill Foreman Kevin Herrmann.

DRILL SETUP
Set up on Savage Rapids Reservoir using custom-built floating drilling platform equipped with pontoons and 35-hp outboard motor.

DRILLING METHODS
Drilled with 10" O.D., 6.25" I.D. hollow-stem flight augers (AP). Took drive samples on approx. 3-foot intervals starting at top of lake bed using 3" I.D. split-tube sample barrel sprayed with PAM aerosol vegetable coating and fitted with basket catcher and plastic baffle. 140-lbm safety hammer and cathead with rope. Sampler allowed to set on hole bottom for 10 minutes before retrieval.

SAMPLE INTERVALS
14.5-16.5' 3" OS
20.7-22.7' 3" OS
25.5-27.4' 3" OS

DRILLING CONDITIONS
0.0-14.5': Set AP through reservoir water.
14.5-25.2': Slow and smooth.
25.2-27.8': Slow and rough. Sampler rebounding with no penetration at 27.4'; augers refused at 27.8' during cleanout run.

CASING RECORD

1999 Date	AP Sz	Depth Hole	Depth AP
9-30	6"	27.8	27.8

FLUID RETURN AND COLOR
No fluid used.

WATER LEVEL DURING DRILLING
Water level stayed at reservoir surface, i.e., 0.0'.

HOLE COMPLETION
Retrieved AP from reservoir bottom, reversing auger rotation to move cuttings back down hole.

DEPTH	TYPE OF HOLE	% CORE RECOVERY	% MINUS #230	VISUAL CLASS	LAB CLASS	FLD CLASS/LITH	ELEVATION
5						Water	
10							
15	DS	0		NoRec	NoRec		953.7
	AP						
20	DS	70	0.05	(SP)g	(SP)g	Qrs	
	AP						
25	DS	53	0.05	(GP)s	(GW)s		940.4
			BOTTOM OF HOLE				
30							

CLASSIFICATION AND PHYSICAL CONDITION

The measuring point for this drill hole was the reservoir water surface; all depths reported on this log correspond to the same measurements reported by the driller.

0.0-14.5': WATER.

14.5-27.8': RESERVOIR SEDIMENTS (Qrs).

14.5-16.5': No recovery. Thin residue of fine to medium sand trapped behind basket catcher of sample barrel.

20.7-22.7': POORLY GRADED SAND WITH GRAVEL (SP)g. About 65% fine to coarse, hard, angular to rounded sand; about 35% fine to coarse, hard, angular to rounded gravel; trace of fines; maximum size, 75 mm; wet, dark gray; includes minor, fine, oxidized organic debris; heterogeneous, dense; particle composition consists of basalt, metavolcanics and quartz with minor granitics; no reaction with HCl. LAB TEST DATA: 80% sand, 19% gravel, 1% fines; Cu = 4.00, Cc = 1.00; SpG = 2.752.

25.5-27.4': POORLY GRADED GRAVEL WITH SAND (GP)s. About 65% fine to coarse, hard, subangular to rounded gravel; about 35% fine to coarse, hard, angular to rounded sand; trace of fines; maximum size, 50 mm; wet, dark gray; includes minor, fine, oxidized organic debris; heterogeneous, loose to dense; particle composition consists of basalt, metavolcanics and quartz; no reaction with HCl. LAB TEST DATA: 54% gravel, 45% sand, 1% fines; Cu = 6.85, Cc = 1.35; SpG = 2.739; laboratory classification of sample is WELL-GRADED GRAVEL WITH SAND (GW)s.

27.8': BOTTOM OF HOLE. Hole drilling very hard and rough from 25.2-27.8'; sampler rebounding with no penetration at 27.4'; augers refused at 27.8' during cleanout run.

NOTES:
1. Geologic descriptors are defined in the Engineering Geology Field Manual, Second Edition, Volume 1 (U.S. Bureau of

COMMENTS:

AP = 10" O.D., 6.25" I.D. hollow-stem flight augers.
DS = Drive Sample — NoRec = No Recovery
Cs = Casing — Sz = Size of Casing
I.D. = Inside Diameter — O.D. = Outside Diameter
Cu = Coefficient of Uniformity — Cc = Coefficient of Curvature
SpG = Specific Gravity (minus #4 fraction)

GEOLOGIC LOG OF DRILL HOLE NO. AP-99-10

FEATURE: Savage Rapids Dam
LOCATION: Reservoir
BEGUN: 9-30-99 FINISHED: 9-30-99
DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED:

PROJECT: Rogue River Basin
COORDINATES: N 286592.5 E 4184704.9
TOTAL DEPTH: 27.8
DEPTH TO BEDROCK:

STATE: Oregon
GROUND ELEVATION: 968.2
ANGLE FROM HORIZONTAL: 90 AZIMUTH:
HOLE LOGGED BY: R. Link
REVIEWED BY:

CLASSIFICATION AND PHYSICAL CONDITION (CONTINUED)	

Reclamation, 1998).

2. Samples were logged in the field using Designation USBR 5005-86, "Procedure for Determining Unified Soil Classification (Visual Method)"; laboratory classifications have been prepared using Designation USBR 5000-86, "Procedure for Determining Unified Soil Classification (Laboratory Method)".

GEOLOGIC LOG OF DRILL HOLE NO. AP-99-11

FEATURE: Savage Rapids Dam
LOCATION: Reservoir
BEGUN: 10-1-99 FINISHED: 10-1-99
DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED:

PROJECT: Rogue River Basin
COORDINATES: N 286337.6 E 4186805.9
TOTAL DEPTH: 22.5
DEPTH TO BEDROCK:

STATE: Oregon
GROUND ELEVATION: 967.8
ANGLE FROM HORIZONTAL: 90 AZIMUTH:
HOLE LOGGED BY: R. Link
REVIEWED BY:

NOTES

PURPOSE OF HOLE
To determine the composition and volume of sediments stored behind Savage Rapids Dam.

DRILL EQUIPMENT
Ingersoll-Rand A200 skid-mounted drill.

DRILLER
Drill Foreman Kevin Herrmann.

DRILL SETUP
Set up on Savage Rapids Reservoir using custom-built floating drilling platform equipped with pontoons and 35-hp outboard motor.

DRILLING METHODS
Drilled with 10" O.D., 6.25" I.D. hollow-stem flight augers (AP). Took drive samples on approx. 3-foot intervals starting at top of lake bed using 3" I.D. split-tube sample barrel sprayed with PAM aerosol vegetable coating and fitted with basket catcher and plastic baffle, 140-lbm safety hammer and cathead with rope. Sampler allowed to set on hole bottom for 10 minutes before retrieval. Heavy metals sampler decontaminated using de-ionized water mixed with 1.25 fluid oz. of Liqui-Nox detergent.

SAMPLE INTERVALS
17.5-19.7' 3" DS
21.0-22.5' 3" DS

DRILLING CONDITIONS
0.0-17.5': Set AP through reservoir water.
17.5-21.0': Slow and smooth.
21.0-22.5': Slow and rough. Sampler rebounding with no penetration at 22.5'; augers refused at 21.1' during cleanout run.

CASING RECORD

1999 Date	Sz	AP Depth Hole	AP Depth
10-1	6"	22.5	21.1

FLUID RETURN AND COLOR
No fluid used.

WATER LEVEL DURING DRILLING
Water level stayed at reservoir surface, i.e., 0.0'.

HOLE COMPLETION
Retrieved AP from

DEPTH	TYPE OF HOLE	% CORE RECOVERY	VISUAL CLASS	LAB CLASS	FLD CLASS/LITH / ELEVATION
5					
10					Water
15					950.3
20	DS *	27	(GP)s	-	Qrs
	AP				
	DS	7	n/a.	n/a	945.3
25	BOTTOM OF HOLE				

CLASSIFICATION AND PHYSICAL CONDITION

The measuring point for this drill hole was the reservoir water surface; all depths reported on this log correspond to the same measurements reported by the driller.

0.0-17.5': WATER.

17.5-22.5': RESERVOIR SEDIMENTS (Qrs).

17.5-19.7': POORLY GRADED GRAVEL WITH SAND (GP)s. About 85% fine to coarse, hard, subangular to rounded gravel; about 15% fine to coarse, hard, angular to rounded sand; trace of fines; maximum size, 60 mm; wet, dark gray; includes minor, fine, oxidized organic debris; heterogeneous, loose; particle composition consists of basalt, metavolcanics and quartz; no reaction with HCl.
NOTES: (1) Sampler sank 0.2' under weight of drill rods at start of sample interval; drove sampler from 17.7-19.7' with safety hammer. (2) This sample submitted for laboratory testing for heavy metals contamination.

21.0-22.5': Poor recovery. Sample composed of gravel and sand; insufficient sample mass to perform a soil classification. Recovered sample consists of about 85% fine to coarse, hard, angular to rounded sand; about 15% fine, hard, subrounded gravel; trace of fines; maximum size, 10 mm; wet, dark gray; heterogeneous, dense; no reaction with HCl.

22.5': BOTTOM OF HOLE. Hole drilling very hard and rough from 21.0-21.1'; sampler rebounding with no penetration at 22.5'; augers refused at 21.1' during cleanout run.

NOTES:
1. Geologic descriptors are defined in the Engineering Geology Field Manual, Second Edition, Volume 1 (U.S. Bureau of Reclamation, 1998).

2. Samples were logged in the field using Designation USBR 5005-86, "Procedure for Determining Unified Soil Classification (Visual Method)"; laboratory classifications have been

COMMENTS:

AP = 10" O.D., 6.25" I.D. hollow-stem flight augers
DS = Drive Sample
Cs = Casing
Sz = Size of Casing
I.D. = Inside Diameter
O.D. = Outside Diameter
Cu = Coefficient of Uniformity
Cc = Coefficient of Curvature
SpG = Specific Gravity (minus #4 fraction)
n/a = Not available; insufficient sample mass to perform soil classification
* = Sample submitted for heavy metals testing

GEOLOGIC LOG OF DRILL HOLE NO. AP-99-11

FEATURE: Savage Rapids Dam
LOCATION: Reservoir
BEGUN: 10-1-99 FINISHED: 10-1-99
DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED:

PROJECT: Rogue River Basin
COORDINATES: N 286337.6 E 4186805.9
TOTAL DEPTH: 22.5
DEPTH TO BEDROCK:

STATE: Oregon
GROUND ELEVATION: 957.8
ANGLE FROM HORIZONTAL: 90 AZIMUTH:
HOLE LOGGED BY: R. Link
REVIEWED BY:

NOTES	CLASSIFICATION AND PHYSICAL CONDITION (CONTINUED)	
reservoir bottom, reversing auger rotation to move cuttings back down hole.	prepared using Designation USBR 5000-86, "Procedure for Determining Unified Soil Classification (Laboratory Method)".	

GEOLOGIC LOG OF DRILL HOLE NO. AP-99-12

FEATURE: Savage Rapids Dam
LOCATION: Reservoir
BEGUN: 10-2-99 FINISHED: 10-2-99
DEPTH AND ELEV OF WATER LEVEL AND DATE MEASURED:

PROJECT: Rogue River Basin
COORDINATES: N 286224 E 4185663
TOTAL DEPTH: 43.1
DEPTH TO BEDROCK:

STATE: Oregon
GROUND ELEVATION: 968.7
ANGLE FROM HORIZONTAL: 90 AZIMUTH:
HOLE LOGGED BY: R. Link
REVIEWED BY:

NOTES

PURPOSE OF HOLE
To determine the composition and volume of sediments stored behind Savage Rapids Dam.

DRILL EQUIPMENT
Ingersoll-Rand A200 skid-mounted drill. .

DRILLER
Drill Foreman Kevin Herrmann.

DRILL SETUP
Set up on Savage Rapids Reservoir using custom-built floating drilling platform equipped with pontoons and 35-hp outboard motor.

DRILLING METHODS
Drilled with 10" O.D., 6.25" I.D. hollow-stem flight augers (AP). Took drive samples on approx. 3-foot intervals starting at top of lake bed using 3" I.D. split-tube sample barrel sprayed with PAM aerosol vegetable coating and fitted with basket catcher and plastic baffle, 140-lbm safety hammer and cathead with rope. Sampler allowed to set on hole bottom for 10 minutes before retrieval (15 minutes for heavy metals samples). Heavy metals sampler decontaminated using de-ionized water mixed with 1.25 fluid oz. of Liqui-Nox detergent prior to each interval, except from 41.1-43.1'.

SAMPLE INTERVALS
26.1-28.9' 3" DS
30.8-32.8' 3" DS
35.7-37.7' 3" DS
41.1-43.1' 3" DS

DRILLING CONDITIONS
0.0-26.1': Set AP through reservoir water.
26.1-31.0': Slow and smooth with several rough and hard areas.
31.0-36.1': Slow and hard.
36.1-41.0': Slow and smooth with minor rough areas.
41.0-43.1': Slow and rough. Augers refused at 42.7' during cleanout run.

CASING RECORD

1999 Date	AP Sz	Depth Hole	Depth AP
10-2	6"	43.1	42.7

FLUID RETURN AND COLOR

DEPTH	TYPE OF HOLE	% CORE RECOVERY	% MINUS #230	VISUAL CLASS	LAB CLASS	FLD CLASS/LITH / ELEVATION
5						
10						
15						Water
20						
25						942.6
	DS *	36	0.05	(SP) g	(SP) g	
30	AP					
	DS	45	0.06	SP	(SP) g	
35	AP					Qrs
	DS *	55	0.2	(SP) g	(SW) g	
40	AP					
	DS *	50	0.2	(SP) g	(SW) g	
			BOTTOM OF HOLE			925.6
45						

CLASSIFICATION AND PHYSICAL CONDITION

The measuring point for this drill hole was the reservoir water surface; all depths reported on this log correspond to the same measurements reported by the driller.

0.0-26.1': WATER.

26.1-43.1': RESERVOIR SEDIMENTS (Qrs).

26.1-28.9': POORLY GRADED SAND WITH GRAVEL (SP)g. About 85% fine to coarse, hard, angular to rounded sand; about 15% predominantly fine, hard, subangular to rounded gravel; trace of fines; maximum size, 30 mm; wet, dark gray; includes several fragments of mostly weathered and discolored to partially oxidized wood measuring up to 110 by 40 by 70 mm in size; heterogeneous, loose; particle composition consists of basalt, metavolcanics and quartz; no reaction with HCl.
LAB TEST DATA: 69% sand, 30% gravel, 1% fines; Cu = 4.47, 0.61; SpG = 2.700.
NOTES: (1) Sampler sank 0.8' under weight of drill rods at start of sample interval; drove sampler from 26.9-28.9' with safety hammer. (2) This sample submitted for laboratory testing for heavy metals contamination.

30.8-32.8': POORLY GRADED SAND (SP)g. About 90% fine to coarse, hard, angular to rounded sand; about 10% fine to coarse, hard, subangular to rounded gravel; trace of fines; maximum size, 55 mm; wet, dark gray; includes minor, fine, oxidized organic debris; heterogeneous, loose; particle composition consists of basalt, metavolcanics and quartz; no reaction with HCl.
LAB TEST DATA: 78% sand, 21% gravel, 1% fines; Cu = 4.47, Cc = 0.94; SpG = 2.709.

35.7-37.7': POORLY GRADED SAND WITH GRAVEL (SP)g. About 85% fine to coarse, hard, angular to rounded sand; about 15% fine, hard, subangular to rounded gravel; trace of fines; maximum size, 15 mm; wet, dark gray; includes minor, fine, oxidized organic debris; stratified, top 0.3' of sample consists of fine to medium sand with about 35%

COMMENTS:

AP = 10" O.D., 6.25" I.D. hollow-stem flight augers
DS = Drive Sample
Cs = Casing
Sz = Size of Casing
I.D. = Inside Diameter
O.D. = Outside Diameter
Cu = Coefficient of Uniformity
Cc = Coefficient of Curvature
SpG = Specific Gravity (minus #4 fraction)
* = Sample submitted for heavy metals testing

GEOLOGIC LOG OF DRILL HOLE NO. AP-99-12

FEATURE: Savage Rapids Dam
LOCATION: Reservoir
BEGUN: 10-2-99 FINISHED: 10-2-99
DEPTH AND ELEV OF WATER LEVEL AND DATE MEASURED:

PROJECT: Rogue River Basin
COORDINATES: N 286224 E 4185663
TOTAL DEPTH: 43.1
DEPTH TO BEDROCK:

STATE: Oregon
GROUND ELEVATION: 968.7
ANGLE FROM HORIZONTAL: 90 AZIMUTH:
HOLE LOGGED BY: R. Link
REVIEWED BY:

NOTES	CLASSIFICATION AND PHYSICAL CONDITION (CONTINUED)	
No fluid used. WATER LEVEL DURING DRILLING Water level stayed at reservoir surface, i.e., 0.0'. HOLE COMPLETION Retrieved AP from reservoir bottom, reversing auger rotation to move cuttings back down hole.	nonplastic fines with rapid dilatancy and weak reaction with HCl, loose; particle composition consists of basalt, metavolcanics and quartz; no reaction with HCl. LAB TEST DATA: 69% sand, 28% gravel, 3% fines; Cu = 13.81, Cc = 1.10; SpG = 2.727; laboratory classification of sample is WELL-GRADED SAND WITH GRAVEL (SW)g. NOTE: This sample submitted for laboratory testing for heavy metals contamination; heavy metals sample taken from top 0.3' of interval. 41.1-43.1': POORLY GRADED SAND WITH GRAVEL (SP)g. About 60% fine to coarse, hard, subangular to rounded sand; about 30% fine to coarse, hard, angular to rounded gravel; about 5% nonplastic fines with rapid dilatancy; maximum size, 70 mm; wet, dark gray; stratified, noted crude layering in sample with gravel fraction concentrated in bottom 0.4' of sample, dense; particle composition consists of basalt, metavolcanics and quartz; no reaction with HCl. LAB TEST DATA: 72% sand, 25% gravel, 3% fines; Cu = 7.25, Cc = 1.24; SpG = 2.749; laboratory classification of sample is WELL-GRADED SAND WITH GRAVEL (SW)g. NOTE: This sample submitted for laboratory testing for heavy metals contamination; sample barrel was not decontaminated prior to interval, but hole attained refusal prior to next scheduled heavy metals sample interval. 43.1': BOTTOM OF HOLE. Hole drilling very hard and rough from 41.1-42.7'; augers refused at 42.7' during cleanout run. NOTES: 1. Geologic descriptors are defined in the Engineering Geology Field Manual, Second Edition, Volume 1 (U.S. Bureau of Reclamation, 1998). 2. Samples were logged in the field using Designation USBR 5005-86, "Procedure for Determining Unified Soil Classification (Visual Method)"; laboratory classifications have been prepared using Designation USBR 5000-86, "Procedure for Determining Unified Soil Classification (Laboratory Method)".	

Attachment C

LABORATORY TEST DATA

7-1415 (10-86)
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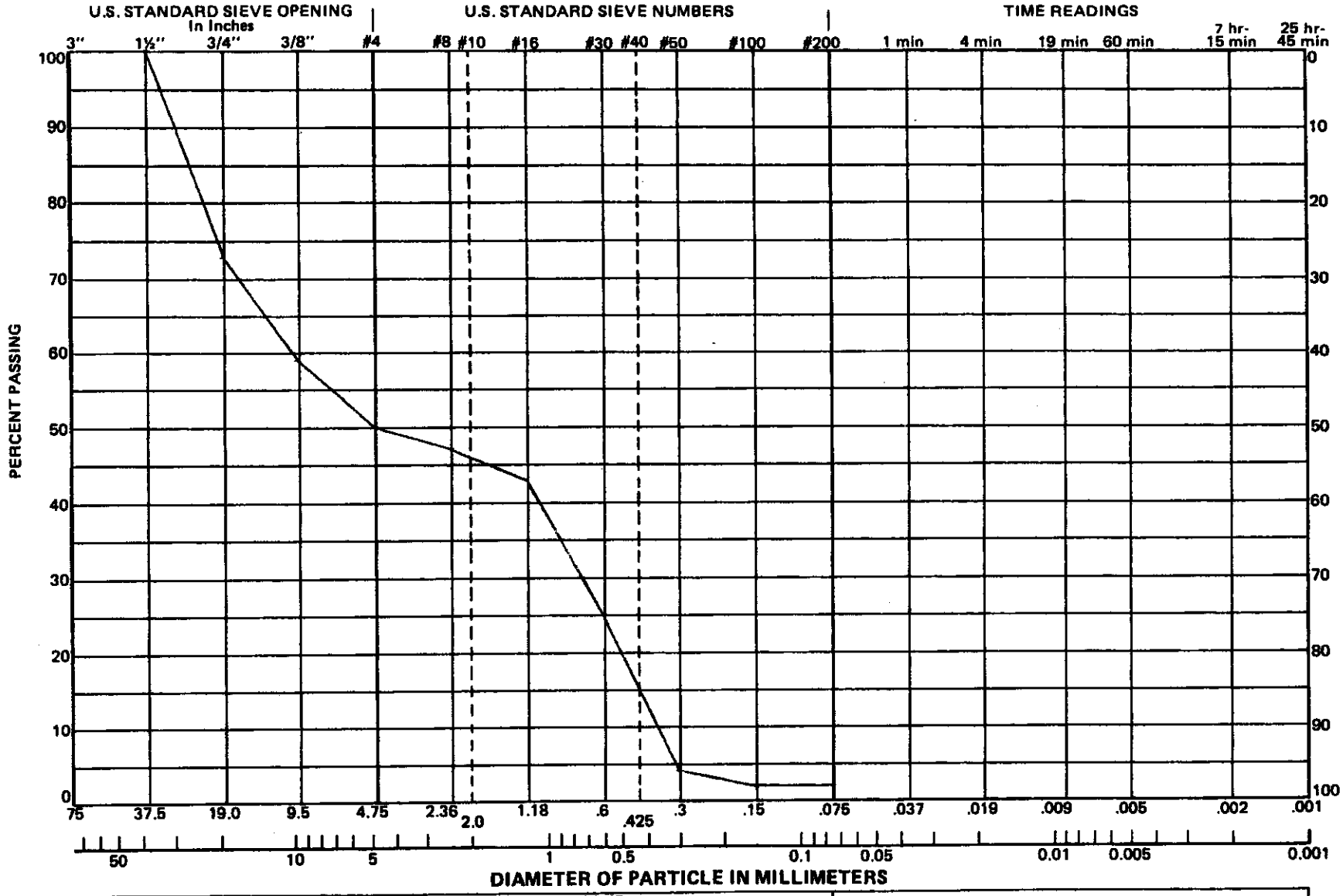
GRADATION TEST

Designation USBR _____ — — —

PREPARED BY _____ CHECKED BY _____ FIGURE _____



SAMPLE NO.	HOLE NO.	ELEV. OR DEPTH ☒ft ☐m	UNIFIED SOIL CLASSIFICATION GROUP SYMBOL	% GRAVEL	% SAND	% FINES	ATTERBERG LIMITS LL (%)	PI (%)	SL (%)	SPECIFIC GRAVITY MINUS NO. 4	OTHER	NOTES:
	AP-91-2	25.0-27.6	(SP)	50	48	2				2.703		

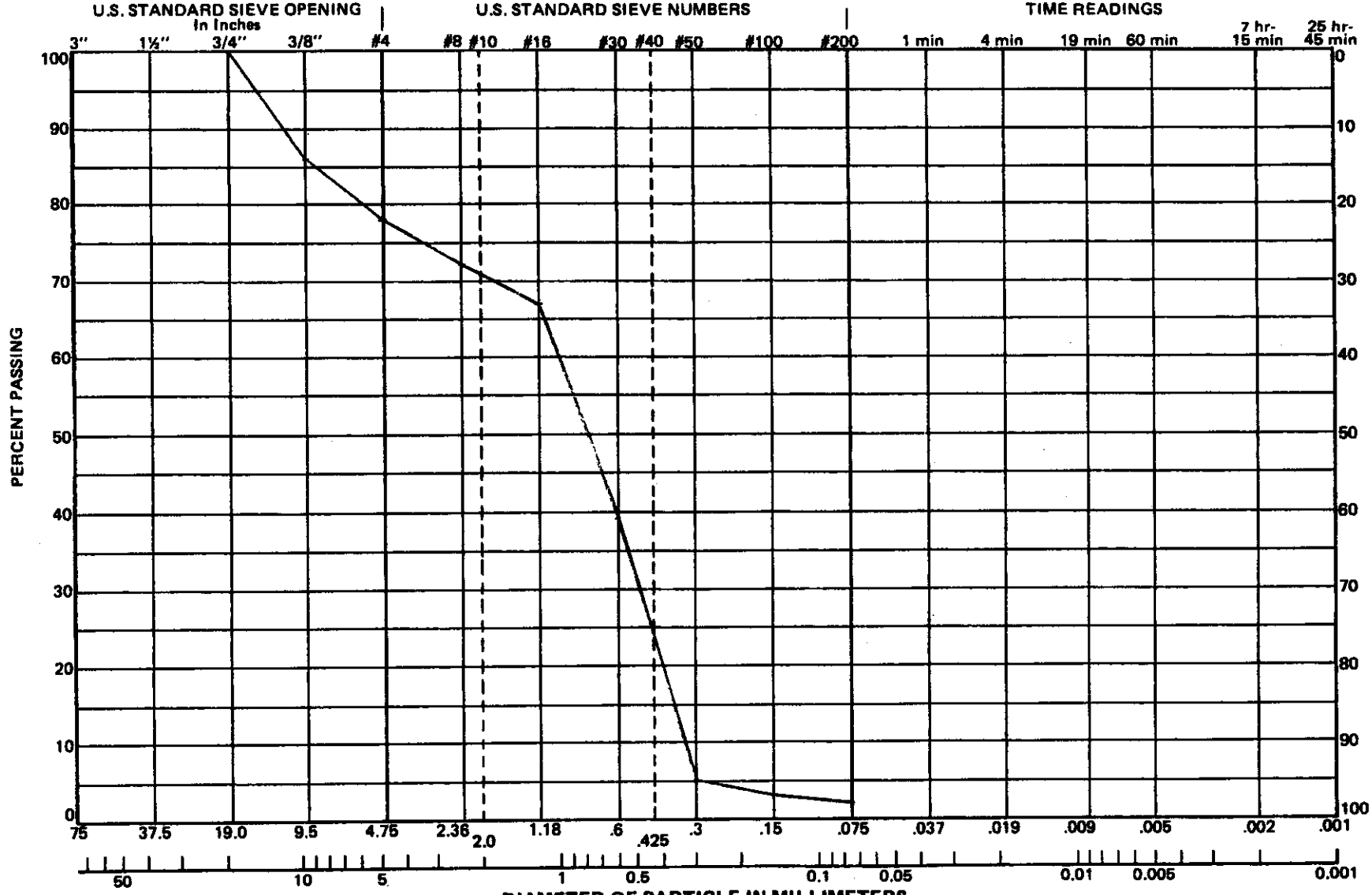
GPO 852-232

7-1415 (10-86)
Bureau of Reclamation

GRADATION TEST

Designation USBR _____ — — —

PREPARED BY _____ CHECKED BY _____ FIGURE _____



GRAVEL		SAND			FINES
COARSE	FINE	COARSE	MEDIUM	FINE	

SAMPLE NO.	HOLE NO.	ELEV. OR DEPTH ☒ft ☐m	UNIFIED SOIL CLASSIFICATION GROUP SYMBOL	% GRAVEL	% SAND	% FINES	ATTERBERG LIMITS LL (%)	PI (%)	SL (%)	SPECIFIC GRAVITY MINUS NO. 4	OTHER	NOTES:
	AP-99-3	26.8-28.8	SP-SM	22	76	2				2.703		

7-1415 (10-86)
Bureau of Reclamation

GRADATION TEST

Designation USBR _____ _ _

PREPARED BY _____ CHECKED BY _____ FIGURE _____

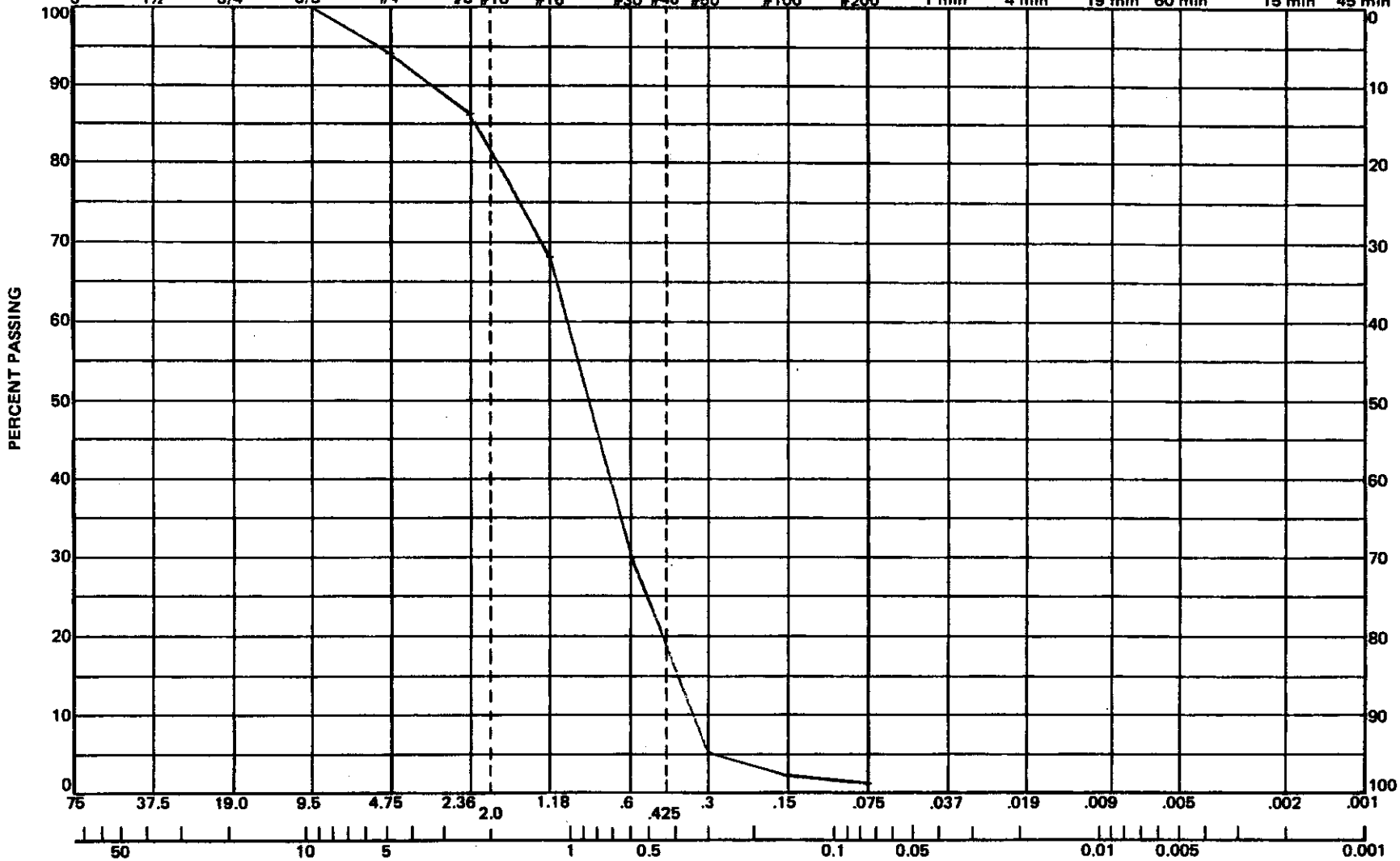
SIEVE ANALYSIS

U.S. STANDARD SIEVE OPENING In Inches: 3" 1½" 3/4" 3/8"

U.S. STANDARD SIEVE NUMBERS: #4 #8 #10 #16 #30 #40 #50 #100 #200

HYDROMETER ANALYSIS

TIME READINGS: 1 min 4 min 19 min 60 min 7 hr-15 min 25 hr-45 min



GRAVEL		SAND			FINES
COARSE	FINE	COARSE	MEDIUM	FINE	

SAMPLE NO.	HOLE NO.	ELEV. OR DEPTH ☒ft ☐m	UNIFIED SOIL CLASSIFICATION				ATTERBERG LIMITS			SPECIFIC GRAVITY		NOTES:
			GROUP SYMBOL	% GRAVEL	% SAND	% FINES	LL (%)	PI (%)	SL (%)	MINUS NO. 4	OTHER	
	NV-92-3	30.2-32.2	SP	6	93	1				2.[illegible]		

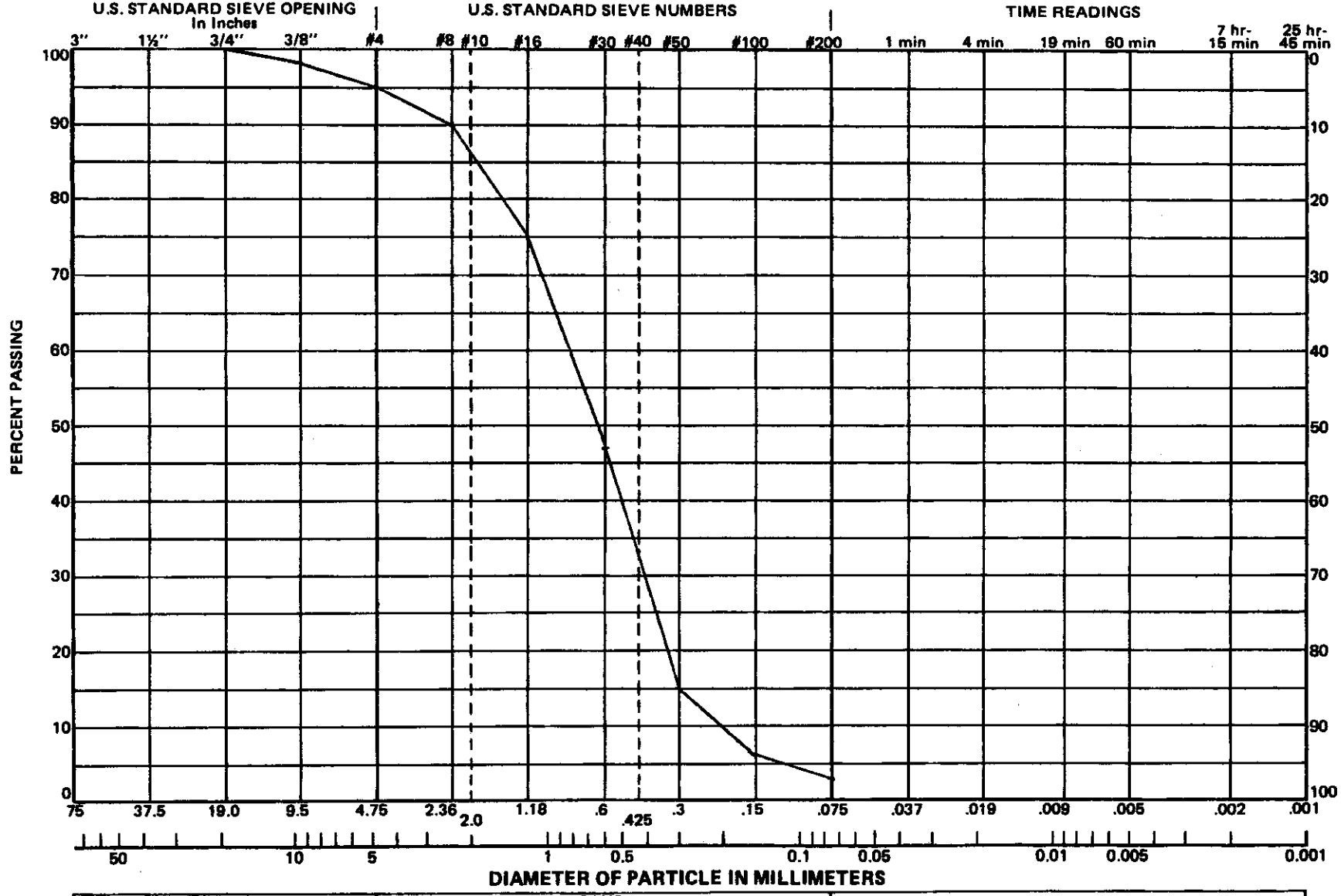
GPO 852-292

7-1415 (10-86)
Bureau of Reclamation

GRADATION TEST

Designation USBR _____ — —

PREPARED BY _____ CHECKED BY _____ FIGURE _____



GRAVEL		SAND			FINES
COARSE	FINE	COARSE	MEDIUM	FINE	

SAMPLE NO.	HOLE NO.	ELEV. OR DEPTH ☒ft ☐m	UNIFIED SOIL CLASSIFICATION				ATTERBERG LIMITS			SPECIFIC GRAVITY		NOTES:
			GROUP SYMBOL	% GRAVEL	% SAND	% FINES	LL (%)	PI (%)	SL (%)	MINUS NO. 4	OTHER	
	AP-99-2	32.5-34.5	SP	5	92	3				2.723		

GPO 852-232

7-1415 (10-86)
Bureau of Reclamation

GRADATION TEST

Designation USBR _____ — —

PREPARED BY _____ CHECKED BY _____ FIGURE _____

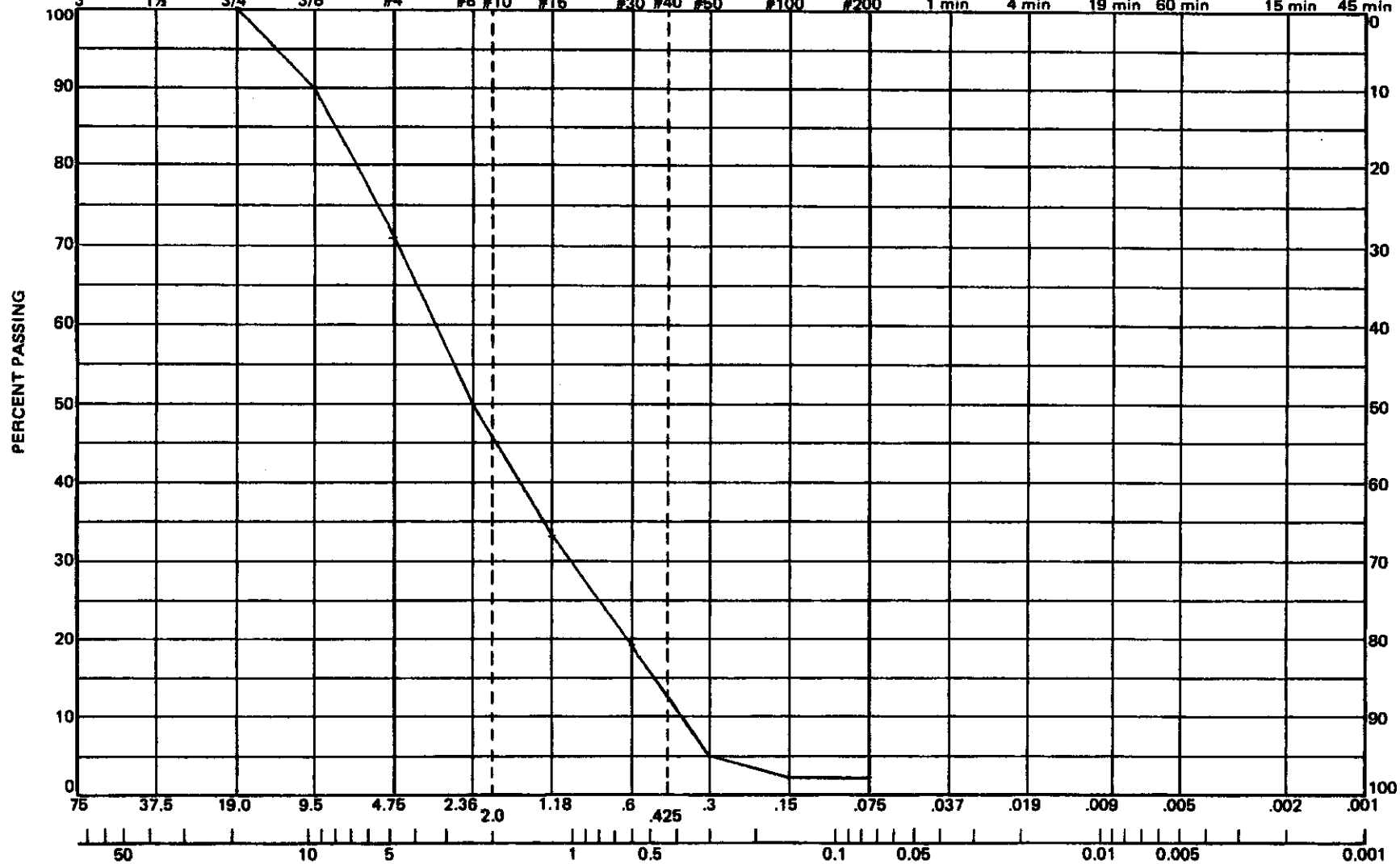
SIEVE ANALYSIS

U.S. STANDARD SIEVE OPENING In Inches: 3" | 1½" | 3/4" | 3/8"

U.S. STANDARD SIEVE NUMBERS: #4 | #8 | #10 | #16 | #30 | #40 | #50 | #100 | #200

HYDROMETER ANALYSIS

TIME READINGS: 1 min | 4 min | 19 min | 60 min | 7 hr- 15 min | 25 hr- 45 min



DIAMETER OF PARTICLE IN MILLIMETERS

GRAVEL		SAND			FINES
COARSE	FINE	COARSE	MEDIUM	FINE	

SAMPLE NO.	HOLE NO.	ELEV. OR DEPTH ☒ft ☐m	UNIFIED SOIL CLASSIFICATION GROUP SYMBOL	% GRAVEL	% SAND	% FINES	ATTERBERG LIMITS LL (%)	PI (%)	SL (%)	SPECIFIC GRAVITY MINUS NO. 4	OTHER	NOTES:
	AP-99-3	35.3-37.3	(SP)4	29	69	2				2.750		

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7-1415 (10-86)
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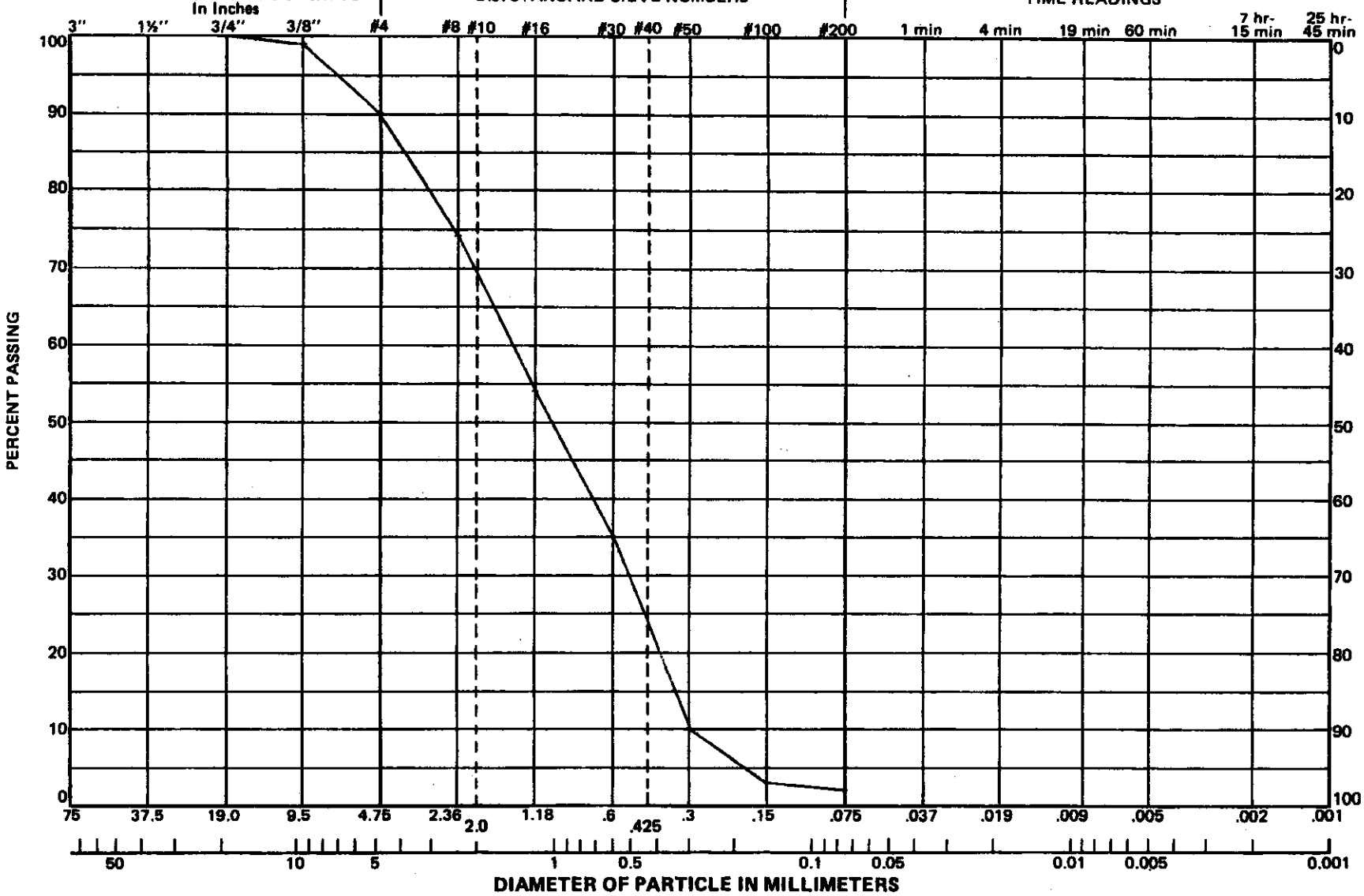
GRADATION TEST

Designation USBR _____ — —

PREPARED BY _____ CHECKED BY _____ FIGURE _____



GRAVEL		SAND			FINES
COARSE	FINE	COARSE	MEDIUM	FINE	

SAMPLE NO.	HOLE NO.	ELEV. OR DEPTH ☒ft ☐m	UNIFIED SOIL CLASSIFICATION GROUP SYMBOL	% GRAVEL	% SAND	% FINES	ATTERBERG LIMITS LL (%)	PI (%)	SL (%)	SPECIFIC GRAVITY MINUS NO. 4	OTHER	NOTES:
	AP-99-3	39.8-39.8	SP	10	88	2				2.790		

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7-1415 (10-86)
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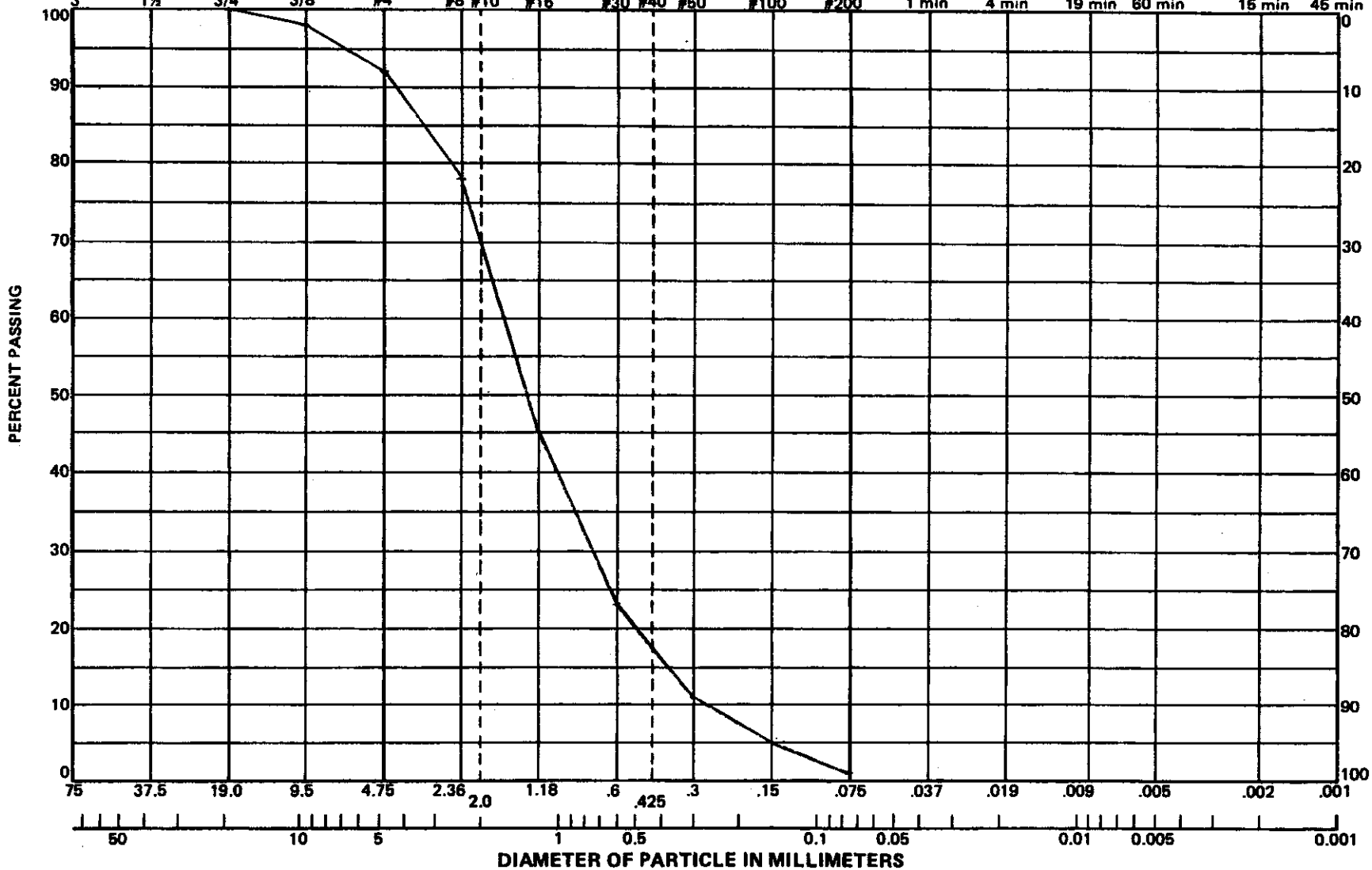
GRADATION TEST

Designation USBR _____ — —

PREPARED BY _____ CHECKED BY _____ FIGURE _____



GRAVEL		SAND			FINES
COARSE	FINE	COARSE	MEDIUM	FINE	

SAMPLE NO.	HOLE NO.	ELEV. OR DEPTH ☒ft ☐m	UNIFIED SOIL CLASSIFICATION GROUP SYMBOL	% GRAVEL	% SAND	% FINES	ATTERBERG LIMITS LL (%)	PI (%)	SL (%)	SPECIFIC GRAVITY MINUS NO. 4	OTHER	NOTES:
	AP-99-3	41.7-43.7	SP	8	91	1				2.738		

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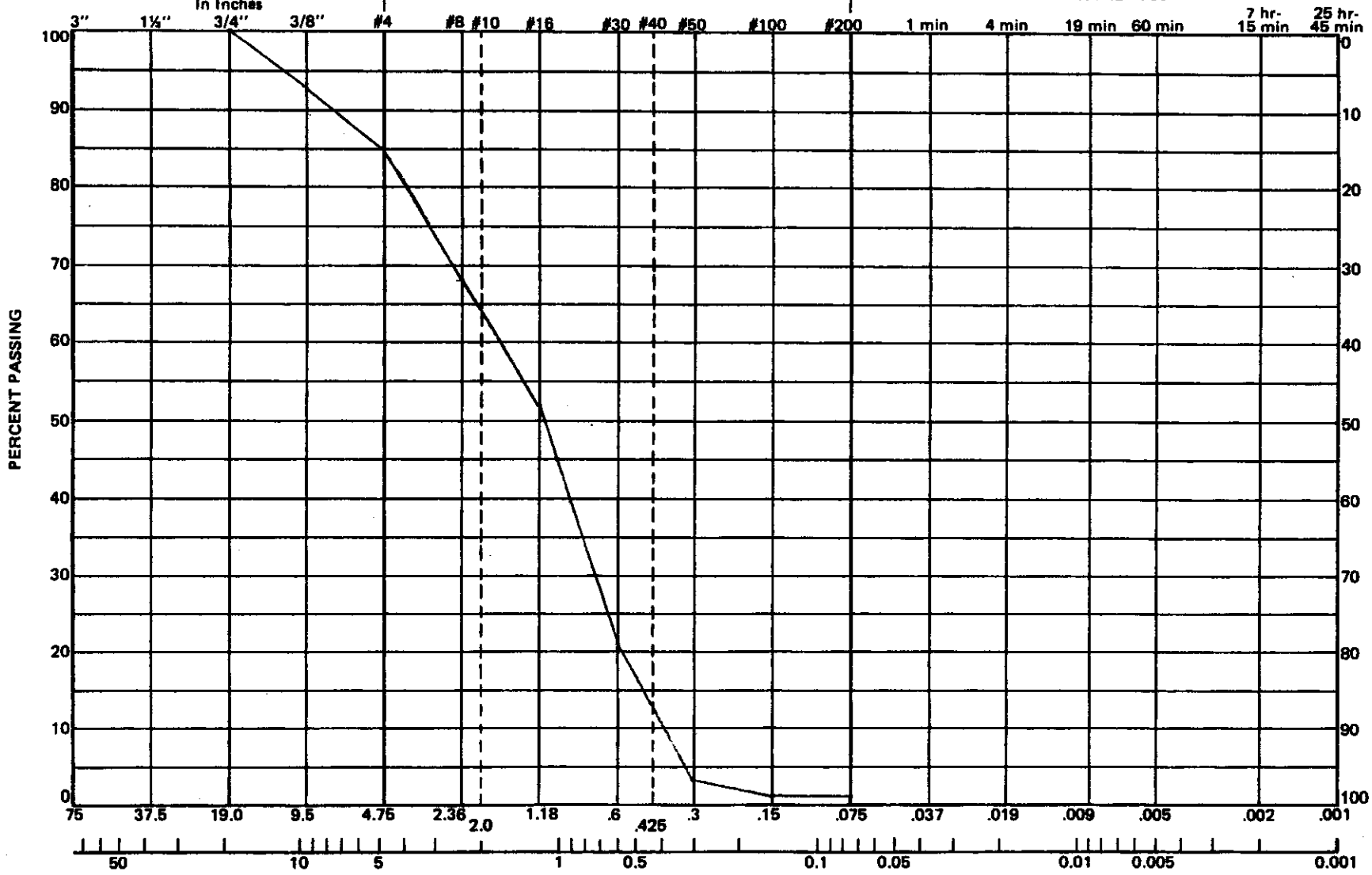
7-1415 (10-86)
Bureau of Reclamation

GRADATION TEST

Designation USBR _____ — —

PREPARED BY _____ CHECKED BY _____ FIGURE _____



GRAVEL		SAND			FINES
COARSE	FINE	COARSE	MEDIUM	FINE	

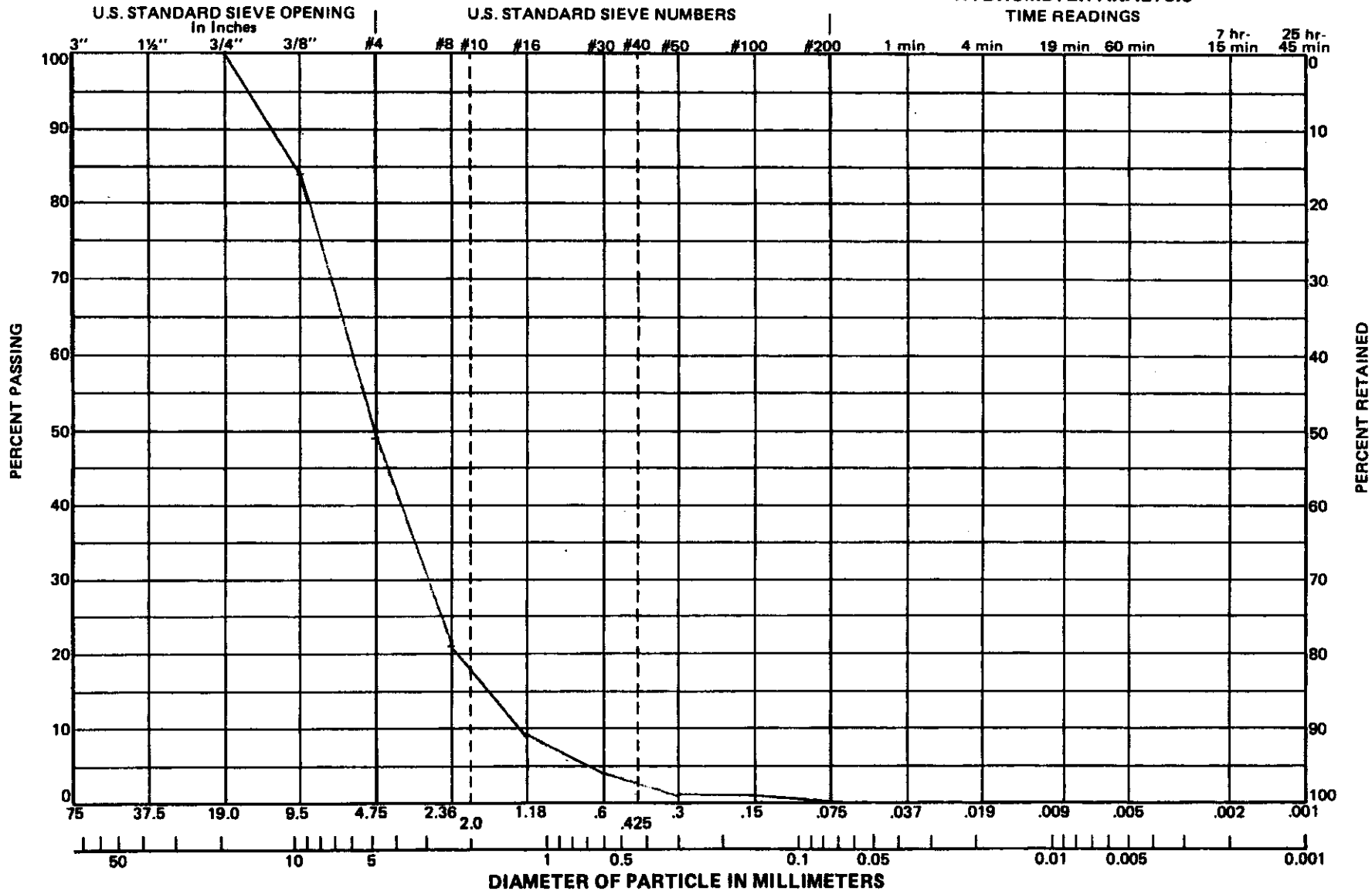
SAMPLE NO.	HOLE NO.	ELEV. OR DEPTH ☑ft ☐m	UNIFIED SOIL CLASSIFICATION GROUP SYMBOL	% GRAVEL	% SAND	% FINES	ATTERBERG LIMITS LL (%)	PI (%)	SL (%)	SPECIFIC GRAVITY MINUS NO. 4	OTHER	NOTES:
	NP-99-5	26.6-28.6	(SP)a	15	84	1				2.695		

7-1415 (10-86)
Bureau of Reclamation

GRADATION TEST

Designation USBR _____ — —

PREPARED BY _____ CHECKED BY _____ FIGURE _____



SAMPLE NO.	HOLE NO.	ELEV. OR DEPTH ☒ft ☐m	UNIFIED SOIL CLASSIFICATION GROUP SYMBOL	% GRAVEL	% SAND	% FINES	ATTERBERG LIMITS LL (%)	PI (%)	SL (%)	SPECIFIC GRAVITY MINUS NO. 4	OTHER	NOTES:
	AP-99-5	31.4-33.4	(GP)-	51	49	0				2.742		

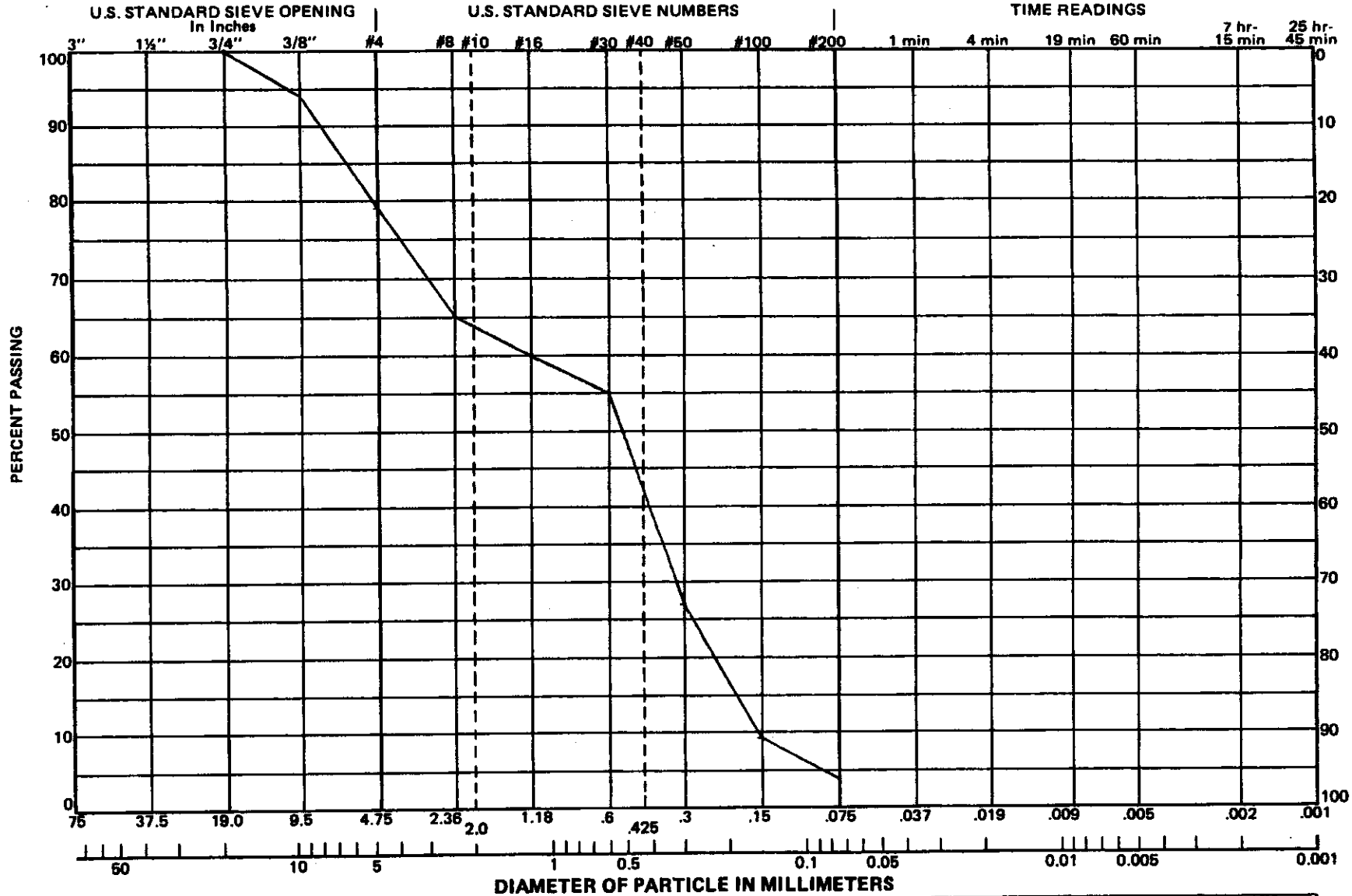
GPO 852-232

7-1415 (10-86)
Bureau of Reclamation

GRADATION TEST

Designation USBR _____ — — —

PREPARED BY _____ CHECKED BY _____ FIGURE _____



GRAVEL		SAND			FINES
COARSE	FINE	COARSE	MEDIUM	FINE	

SAMPLE NO.	HOLE NO.	ELEV. OR DEPTH ☒ft ☐m	UNIFIED SOIL CLASSIFICATION				ATTERBERG LIMITS			SPECIFIC GRAVITY		NOTES:
			GROUP SYMBOL	% GRAVEL	% SAND	% FINES	LL (%)	PI (%)	SL (%)	MINUS NO. 4	OTHER	
	AP-99-5	35.8-37.8	[illegible]	21	75	4				2.727		

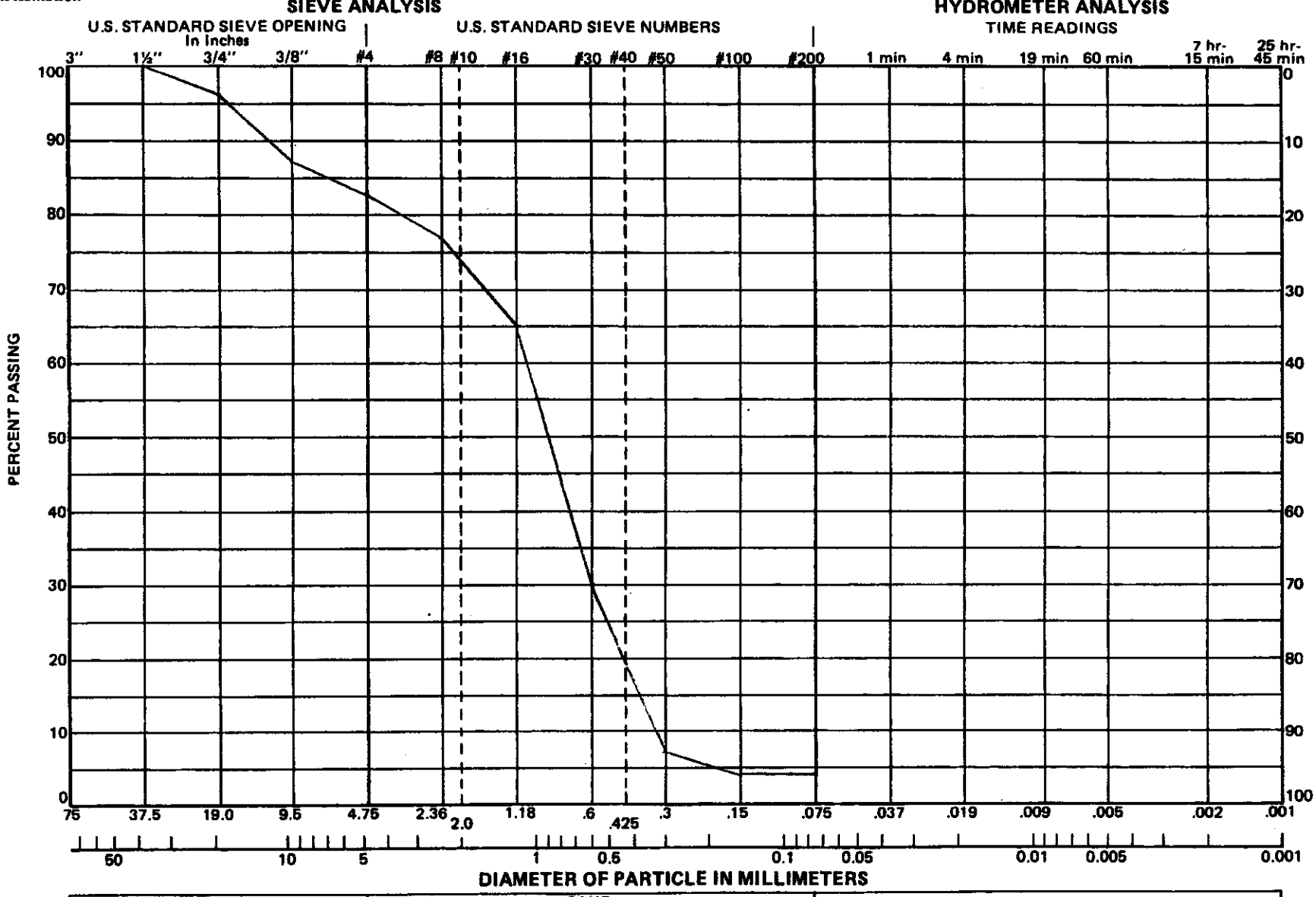
GPO 854-232

7-1415 (10-86)
Bureau of Reclamation

GRADATION TEST

Designation USBR _____

PREPARED BY _____ CHECKED BY _____ FIGURE _____



SAMPLE NO.	HOLE NO.	ELEV. OR DEPTH ☒ft ☐m	UNIFIED SOIL CLASSIFICATION GROUP SYMBOL	% GRAVEL	% SAND	% FINES	ATTERBERG LIMITS LL (%)	PI (%)	SL (%)	SPECIFIC GRAVITY MINUS NO. 4	OTHER	NOTES:
	AP-99-6	21.7-23.7	(SP)	17	79	4				2.666		

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7-1415 (10-86)
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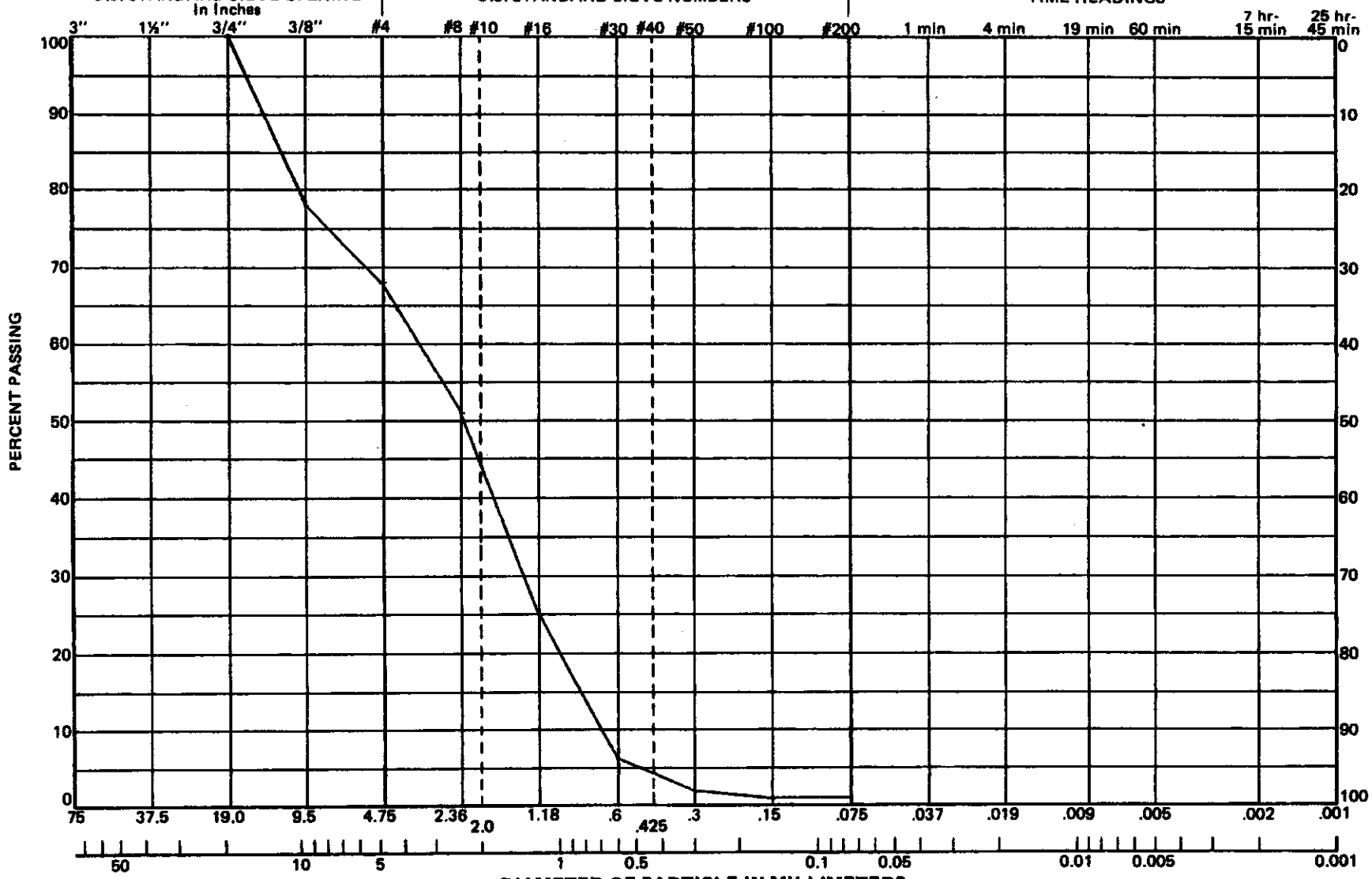
GRADATION TEST

Designation USBR _____

PREPARED BY _____ CHECKED BY _____ FIGURE _____



GRAVEL		SAND			FINES
COARSE	FINE	COARSE	MEDIUM	FINE	

SAMPLE NO.	HOLE NO.	ELEV. OR DEPTH ☒ft ☐m	UNIFIED SOIL CLASSIFICATION				ATTERBERG LIMITS			SPECIFIC GRAVITY		NOTES:
			GROUP SYMBOL	% GRAVEL	% SAND	% FINES	LL (%)	PI (%)	SL (%)	MINUS NO. 4	OTHER	
	AP-99-6	25.9-27.9	(SP)$_g$	32	67	1				2.854		

7-1415 (10-86)
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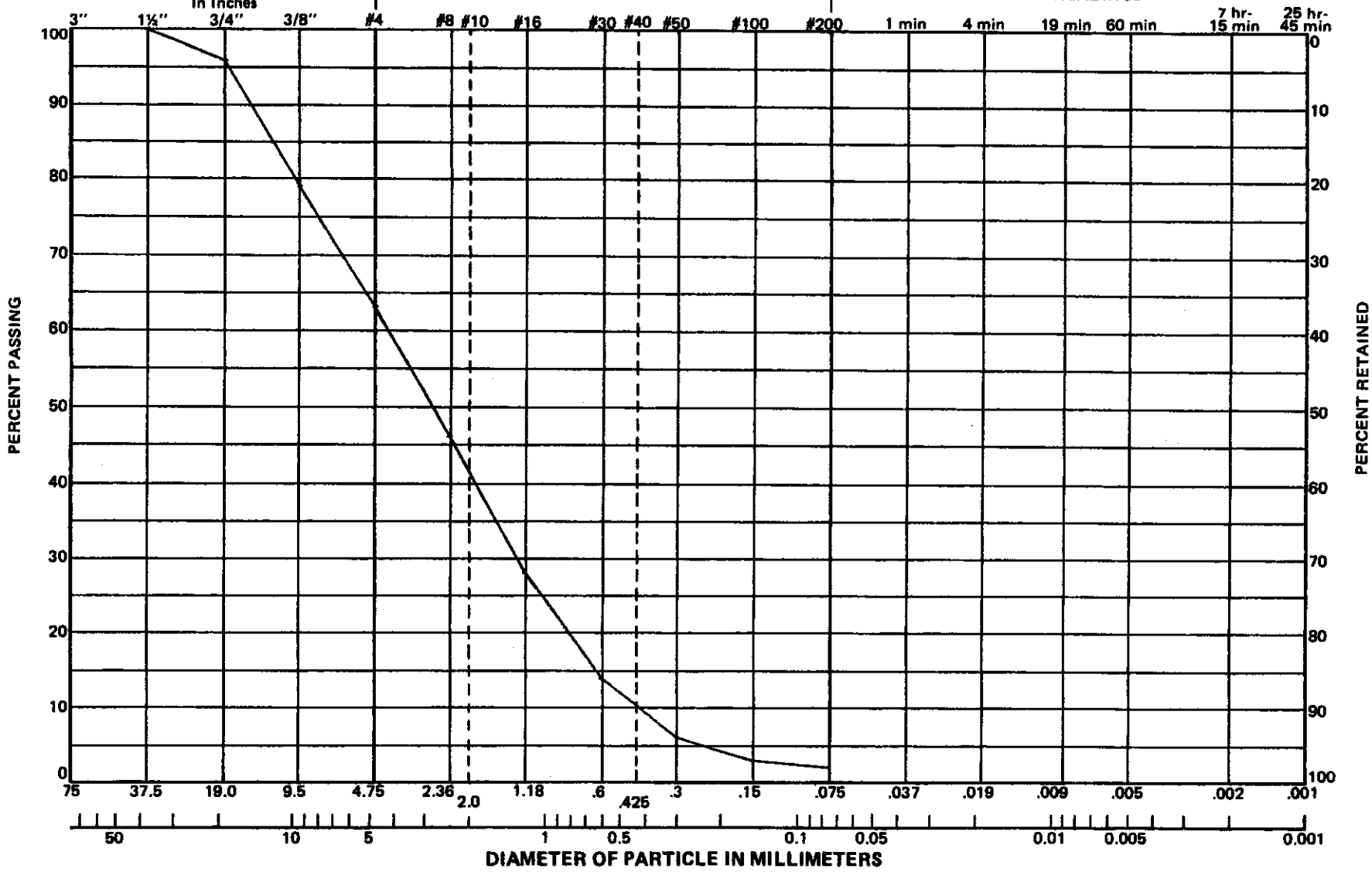
GRADATION TEST

Designation USBR _____ _ _

PREPARED BY _____ CHECKED BY _____ FIGURE _____



GRAVEL		SAND			FINES
COARSE	FINE	COARSE	MEDIUM	FINE	

SAMPLE NO.	HOLE NO.	ELEV. OR DEPTH ☒ft ☐m	UNIFIED SOIL CLASSIFICATION GROUP SYMBOL	% GRAVEL	% SAND	% FINES	ATTERBERG LIMITS LL (%)	PI (%)	SL (%)	SPECIFIC GRAVITY MINUS NO. 4	OTHER	NOTES:
	AP-AA-6	31.1-33.1	(SM)	37	61	2				2.754		

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7-1415 (10-86)
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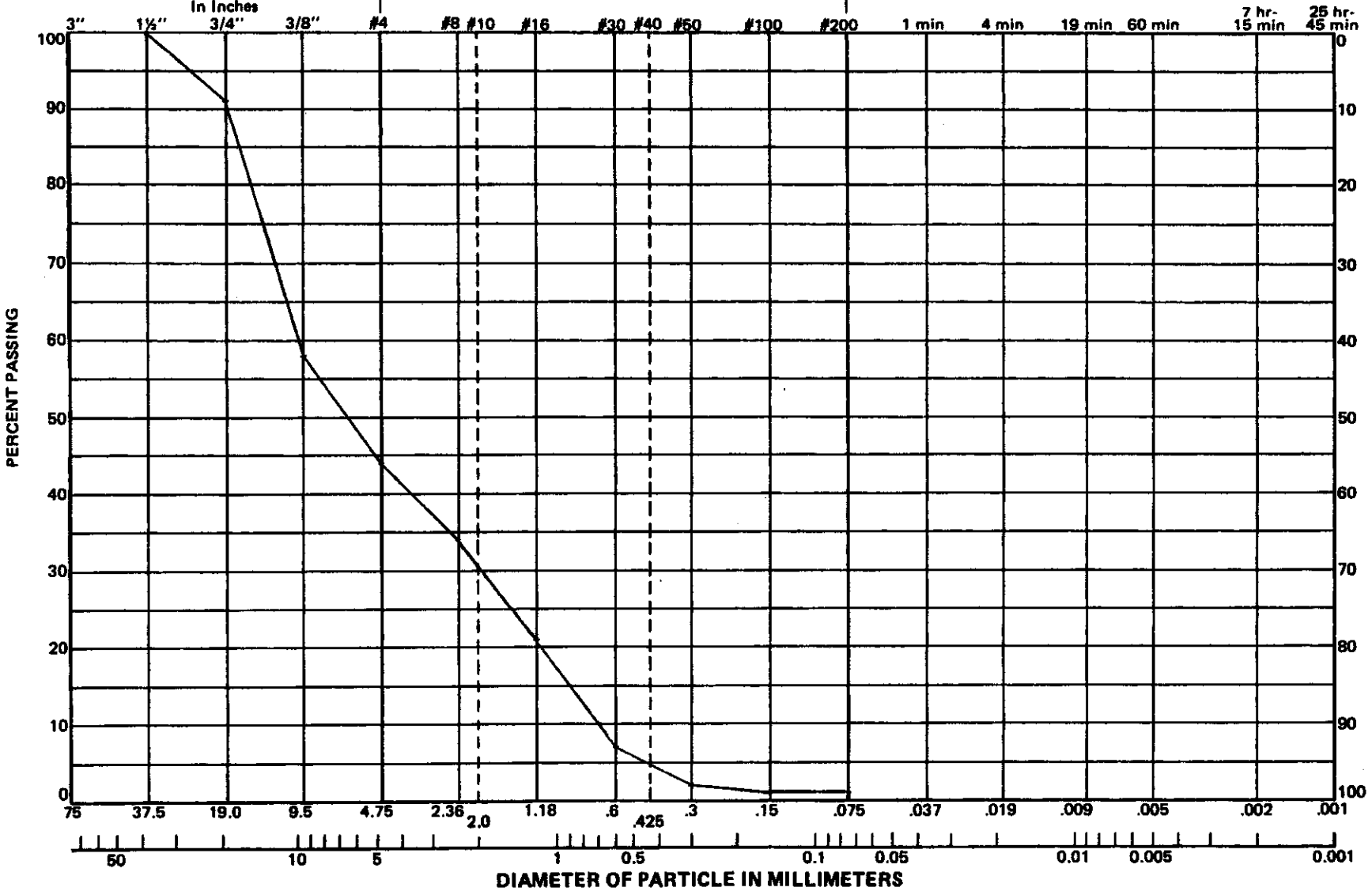
GRADATION TEST

Designation USBR _____ — —

PREPARED BY _____ CHECKED BY _____ FIGURE _____



GRAVEL		SAND			FINES
COARSE	FINE	COARSE	MEDIUM	FINE	

SAMPLE NO.	HOLE NO.	ELEV. OR DEPTH ☒ft ☐m	UNIFIED SOIL CLASSIFICATION GROUP SYMBOL	% GRAVEL	% SAND	% FINES	ATTERBERG LIMITS LL (%)	PI (%)	SL (%)	SPECIFIC GRAVITY MINUS NO. 4	OTHER	NOTES:
	NP-99-7	18.3-20.8	(GW)2	56	43	1				2.714		

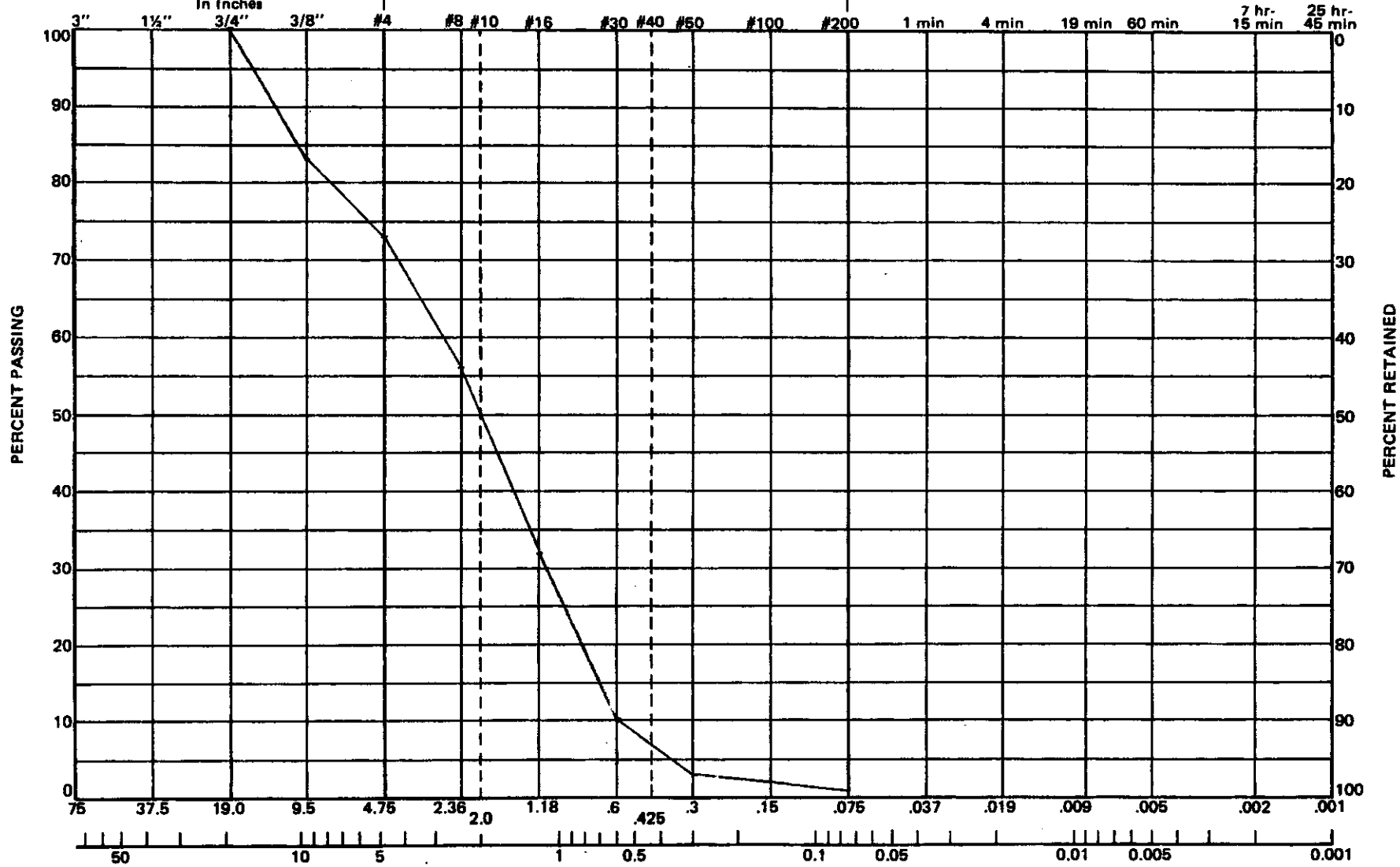
GPO

7-1415 (10-86)
Bureau of Reclamation

GRADATION TEST

Designation USBR _____ — —

PREPARED BY _____ CHECKED BY _____ FIGURE _____



GRAVEL		SAND			FINES
COARSE	FINE	COARSE	MEDIUM	FINE	

SAMPLE NO.	HOLE NO.	ELEV. OR DEPTH ☑ft ☐m	UNIFIED SOIL CLASSIFICATION				ATTERBERG LIMITS			SPECIFIC GRAVITY		NOTES:
			GROUP SYMBOL	% GRAVEL	% SAND	% FINES	LL (%)	PI (%)	SL (%)	MINUS NO. 4	OTHER	
	AP-99-7	22.6-24.6	(SP)$_2$	27	72	1				2.71*		

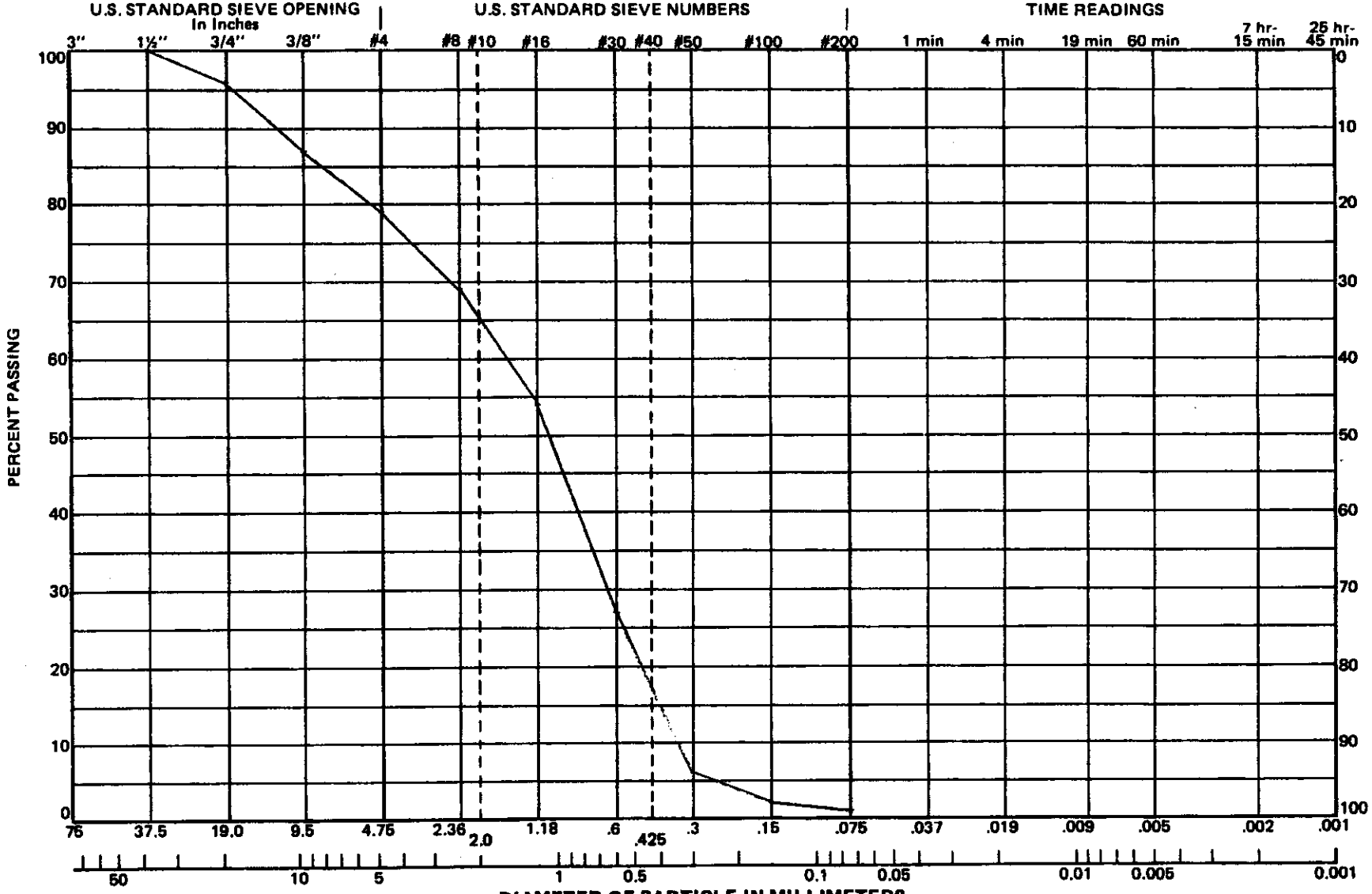
GPO 852-232

7-1415 (10-86)
Bureau of Reclamation

GRADATION TEST

Designation USBR _____ — —

PREPARED BY _____ CHECKED BY _____ FIGURE _____



GRAVEL		SAND			FINES
COARSE	FINE	COARSE	MEDIUM	FINE	

SAMPLE NO.	HOLE NO.	ELEV. OR DEPTH ☒ft ☐m	UNIFIED SOIL CLASSIFICATION GROUP SYMBOL	% GRAVEL	% SAND	% FINES	ATTERBERG LIMITS LL (%)	PI (%)	SL (%)	SPECIFIC GRAVITY MINUS NO. 4	OTHER	NOTES:
	AV-99-S	22.0-24.0	(SI	11	78	1				2.700		

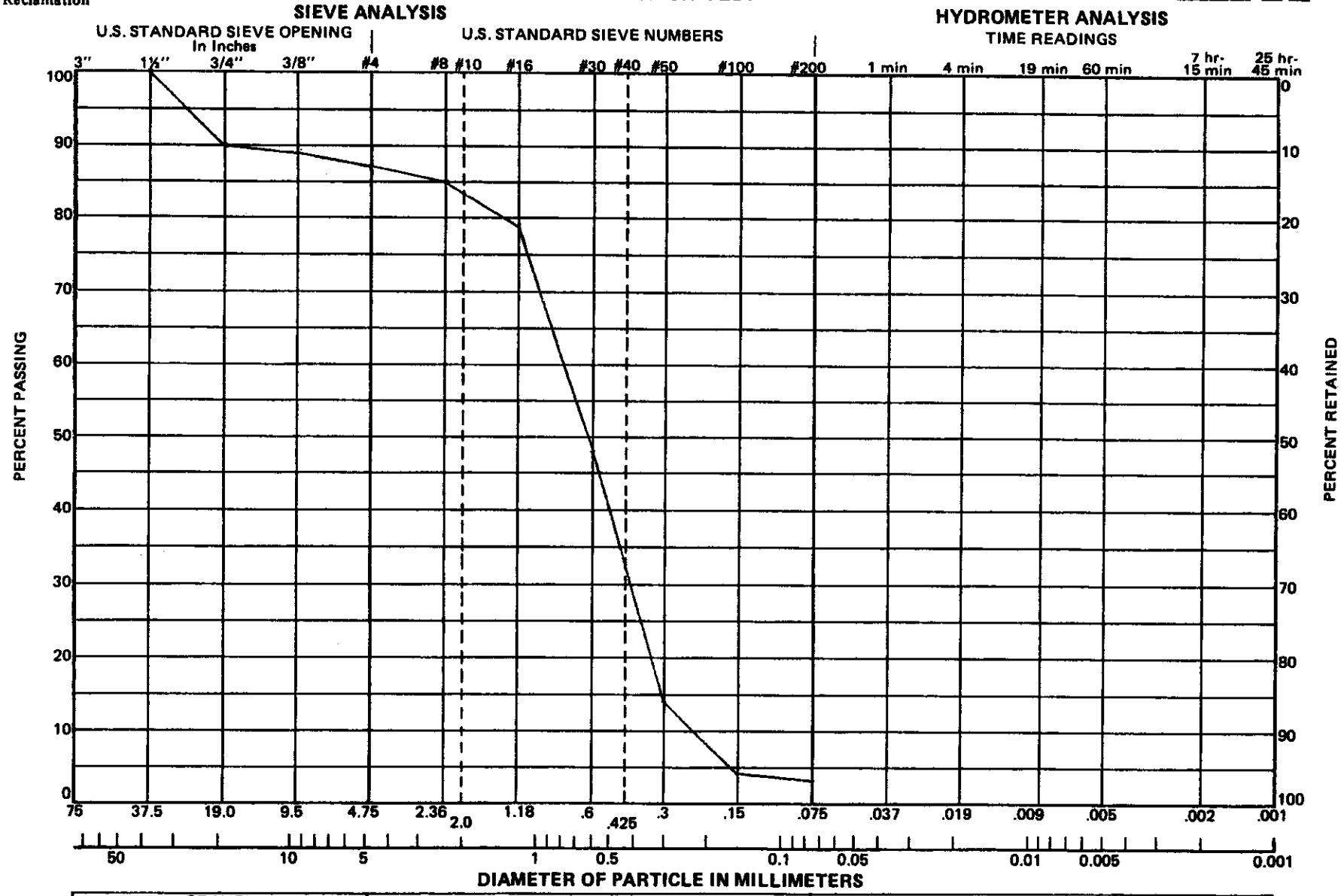
GPO 82

7-1415 (10-86)
Bureau of Reclamation

GRADATION TEST

Designation USBR _____ _____

PREPARED BY _____ CHECKED BY _____ FIGURE _____



GRAVEL		SAND			FINES
COARSE	FINE	COARSE	MEDIUM	FINE	

SAMPLE NO.	HOLE NO.	ELEV. OR DEPTH ☒ft ☐m	UNIFIED SOIL CLASSIFICATION				ATTERBERG LIMITS			SPECIFIC GRAVITY		NOTES:
			GROUP SYMBOL	% GRAVEL	% SAND	% FINES	LL (%)	PI (%)	SL (%)	MINUS NO. 4	OTHER	
	AP-99-8	25.9-27.9	SM	13	84	3				2.685		

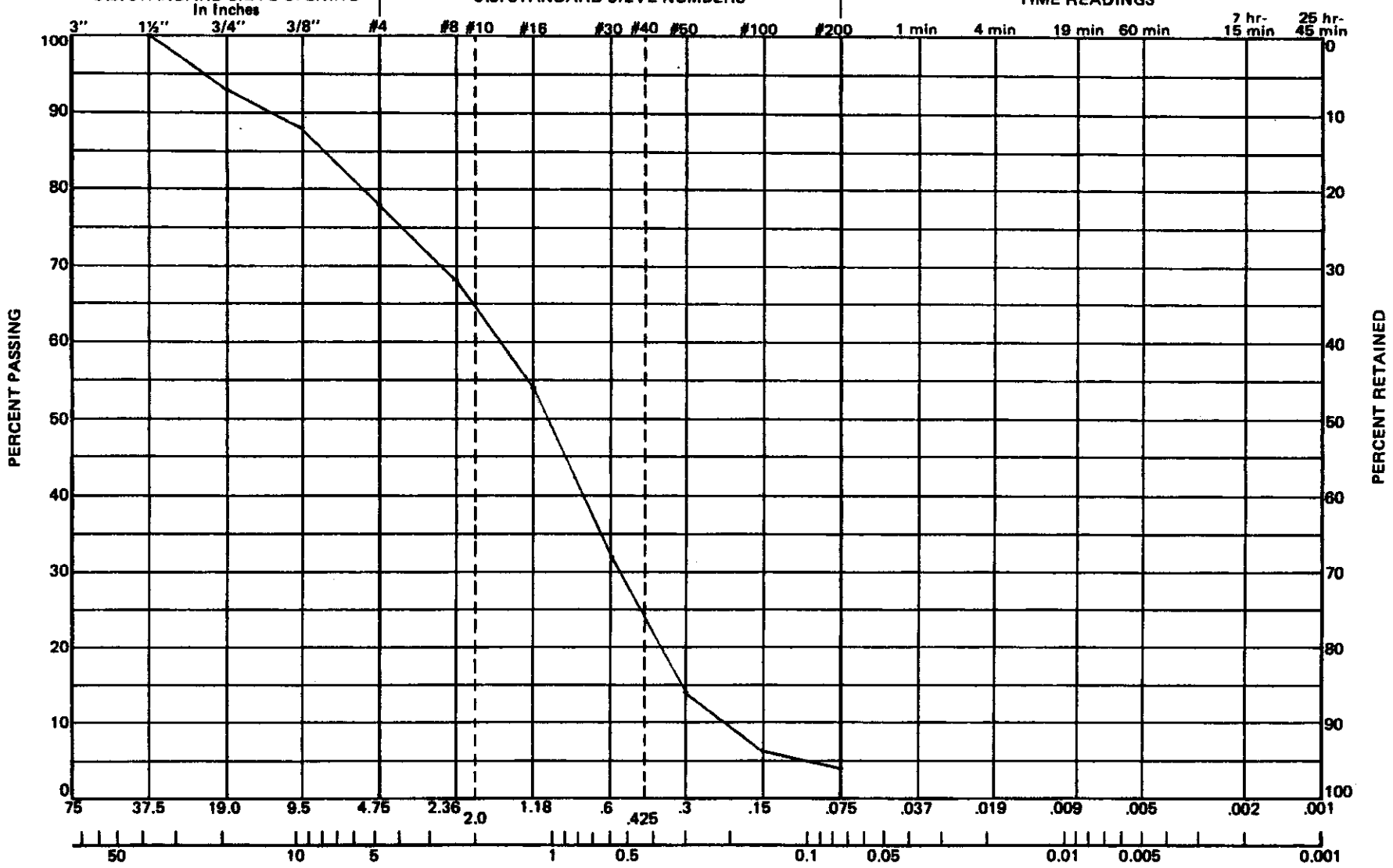
GPO 852-232

7-1415 (10-86)
Bureau of Reclamation

GRADATION TEST

Designation USBR _____ — — —

PREPARED BY _____ CHECKED BY _____ FIGURE _____



SAMPLE NO.	HOLE NO.	ELEV. OR DEPTH ☒ft ☐m	UNIFIED SOIL CLASSIFICATION				ATTERBERG LIMITS			SPECIFIC GRAVITY		NOTES:
			GROUP SYMBOL	% GRAVEL	% SAND	% FINES	LL (%)	PI (%)	SL (%)	MINUS NO. 4	OTHER	
	NV-99-8	29.9-31.6	(SP)	22	74	4				2.739		

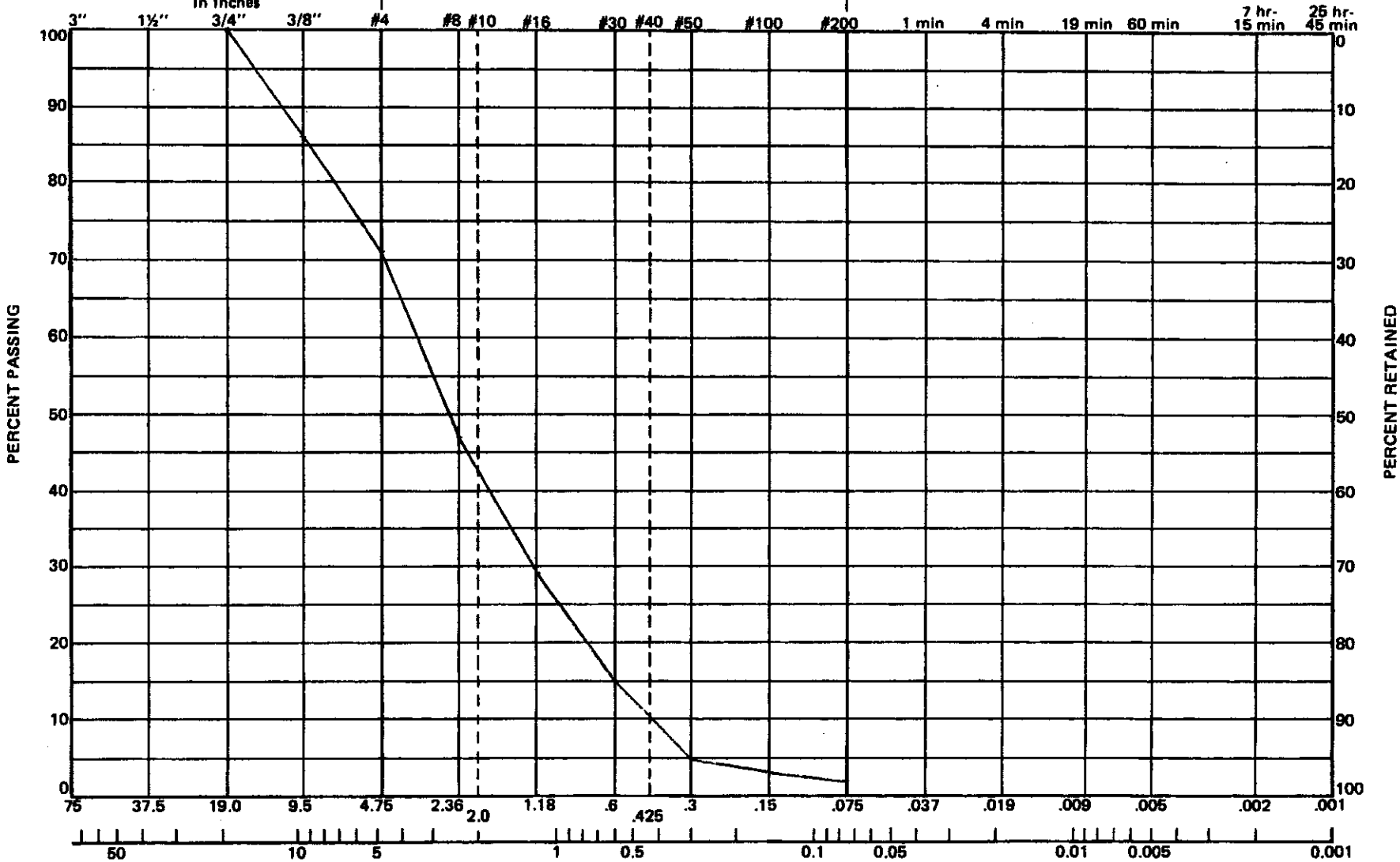
GPO 852-232

7-1415 (10-86)
Bureau of Reclamation

GRADATION TEST

Designation USBR _____ — — —

PREPARED BY _____ CHECKED BY _____ FIGURE _____



SAMPLE NO.	HOLE NO.	ELEV. OR DEPTH ☒ft ☐m	UNIFIED SOIL CLASSIFICATION GROUP SYMBOL	% GRAVEL	% SAND	% FINES	ATTERBERG LIMITS LL (%)	PI (%)	SL (%)	SPECIFIC GRAVITY MINUS NO. 4	OTHER	NOTES:
	AP-99-9	24.7-26.7	(SW)g	29	69	2				2.715		

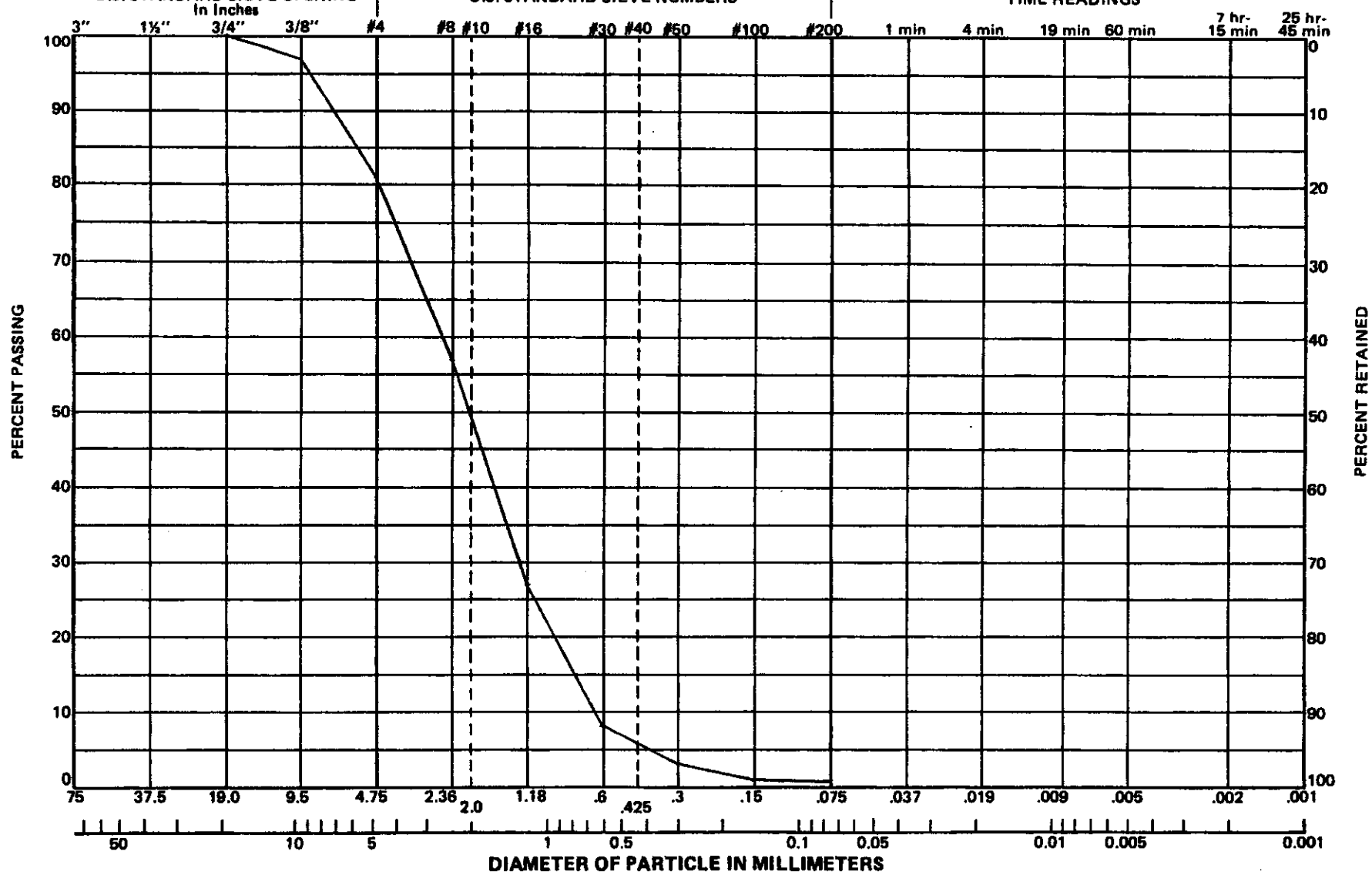
GPO 852-232

7-1415 (10-86)
Bureau of Reclamation

GRADATION TEST

Designation USBR _____ — — —

PREPARED BY _____ CHECKED BY _____ FIGURE _____



GRAVEL		SAND			FINES
COARSE	FINE	COARSE	MEDIUM	FINE	

SAMPLE NO.	HOLE NO.	ELEV. OR DEPTH ☒ft ☐m	UNIFIED SOIL CLASSIFICATION				ATTERBERG LIMITS			SPECIFIC GRAVITY		NOTES:
			GROUP SYMBOL	% GRAVEL	% SAND	% FINES	LL (%)	PI (%)	SL (%)	MINUS NO. 4	OTHER	
	AP-99-10	20.7-22.7	(SP)$_g$	19	80	1				2.752		

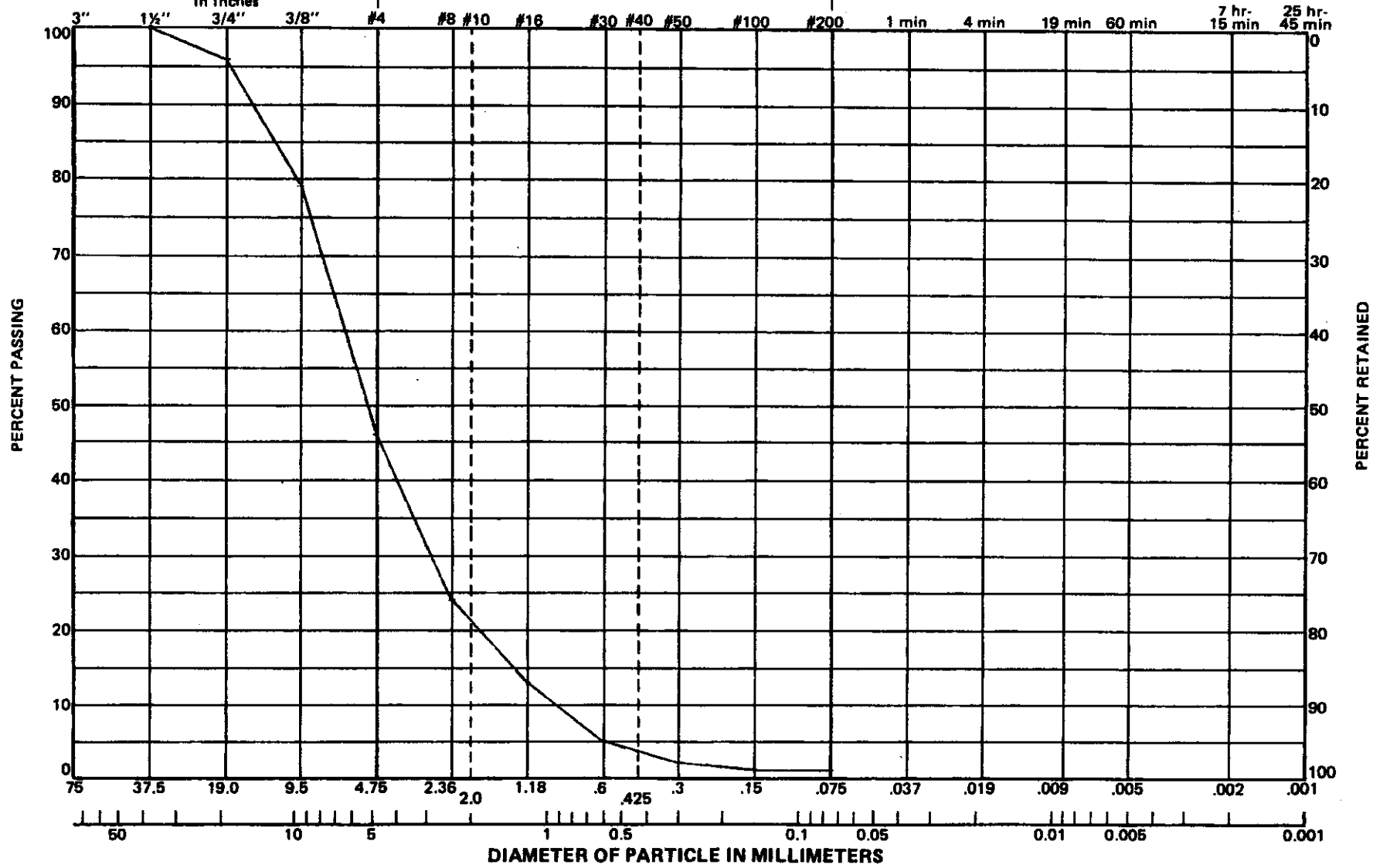
GPO 852-232

7-1415 (10-86)
Bureau of Reclamation

GRADATION TEST

Designation USBR _____ — —

PREPARED BY _____ CHECKED BY _____ FIGURE _____



GRAVEL		SAND			FINES
COARSE	FINE	COARSE	MEDIUM	FINE	

SAMPLE NO.	HOLE NO.	ELEV. OR DEPTH ☒ft ☐m	UNIFIED SOIL CLASSIFICATION GROUP SYMBOL	% GRAVEL	% SAND	% FINES	ATTERBERG LIMITS LL (%)	PI (%)	SL (%)	SPECIFIC GRAVITY MINUS NO. 4	OTHER	NOTES:
	AP-99-10	25.5-27.4	(GW)S	54	45	1				2.739		

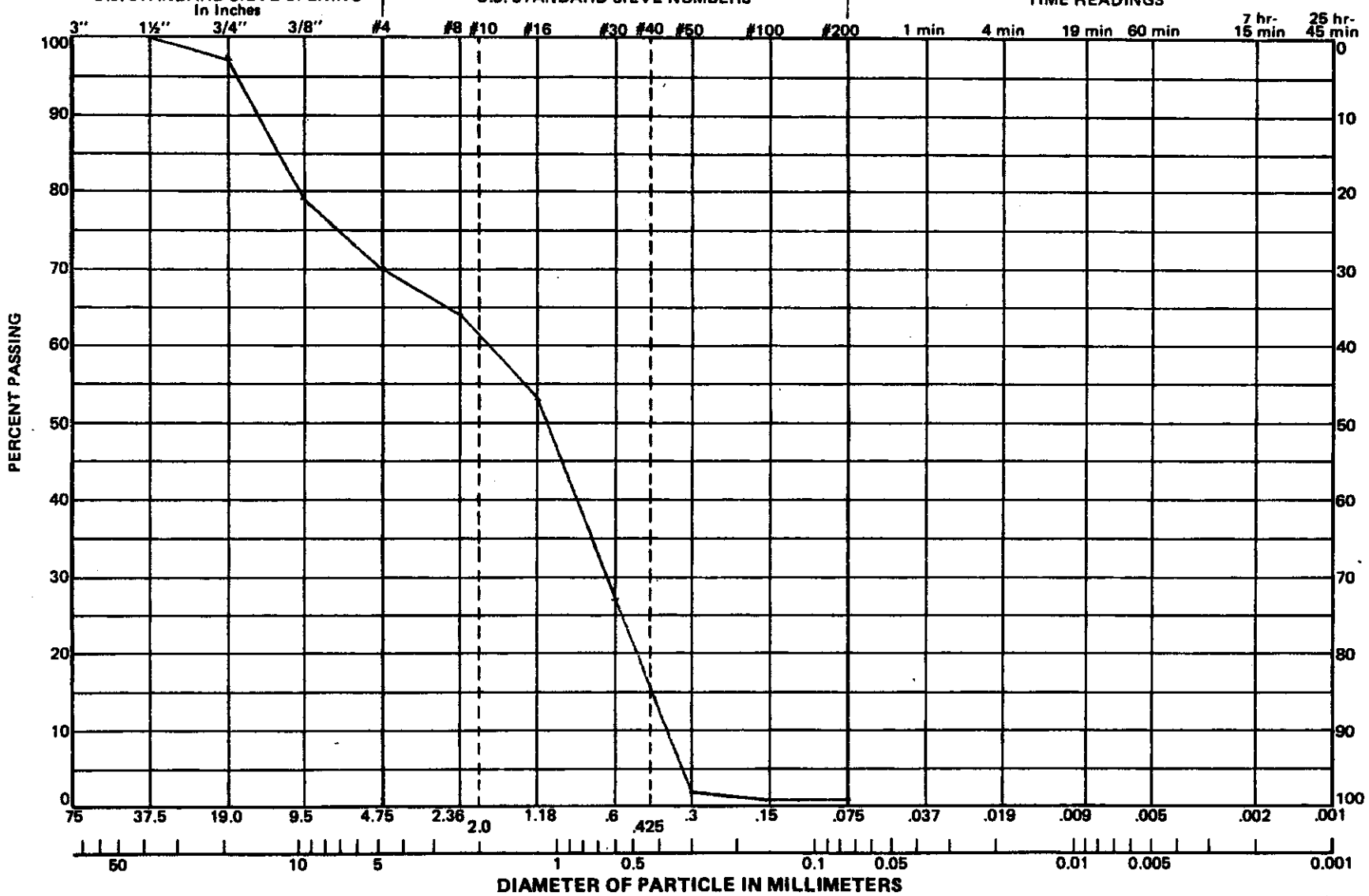
GPO 852-232

7-1415 (10-86)
Bureau of Reclamation

GRADATION TEST

Designation USBR _____ — —

PREPARED BY _____ CHECKED BY _____ FIGURE _____



GRAVEL		SAND			FINES
COARSE	FINE	COARSE	MEDIUM	FINE	

SAMPLE NO.	HOLE NO.	ELEV. OR DEPTH ☒ft ☐m	UNIFIED SOIL CLASSIFICATION GROUP SYMBOL	% GRAVEL	% SAND	% FINES	ATTERBERG LIMITS LL (%)	PI (%)	SL (%)	SPECIFIC GRAVITY MINUS NO. 4	OTHER	NOTES:
	AP-99-12	26.1-28.9	(SP)$_g$	30	69	1				2.700		

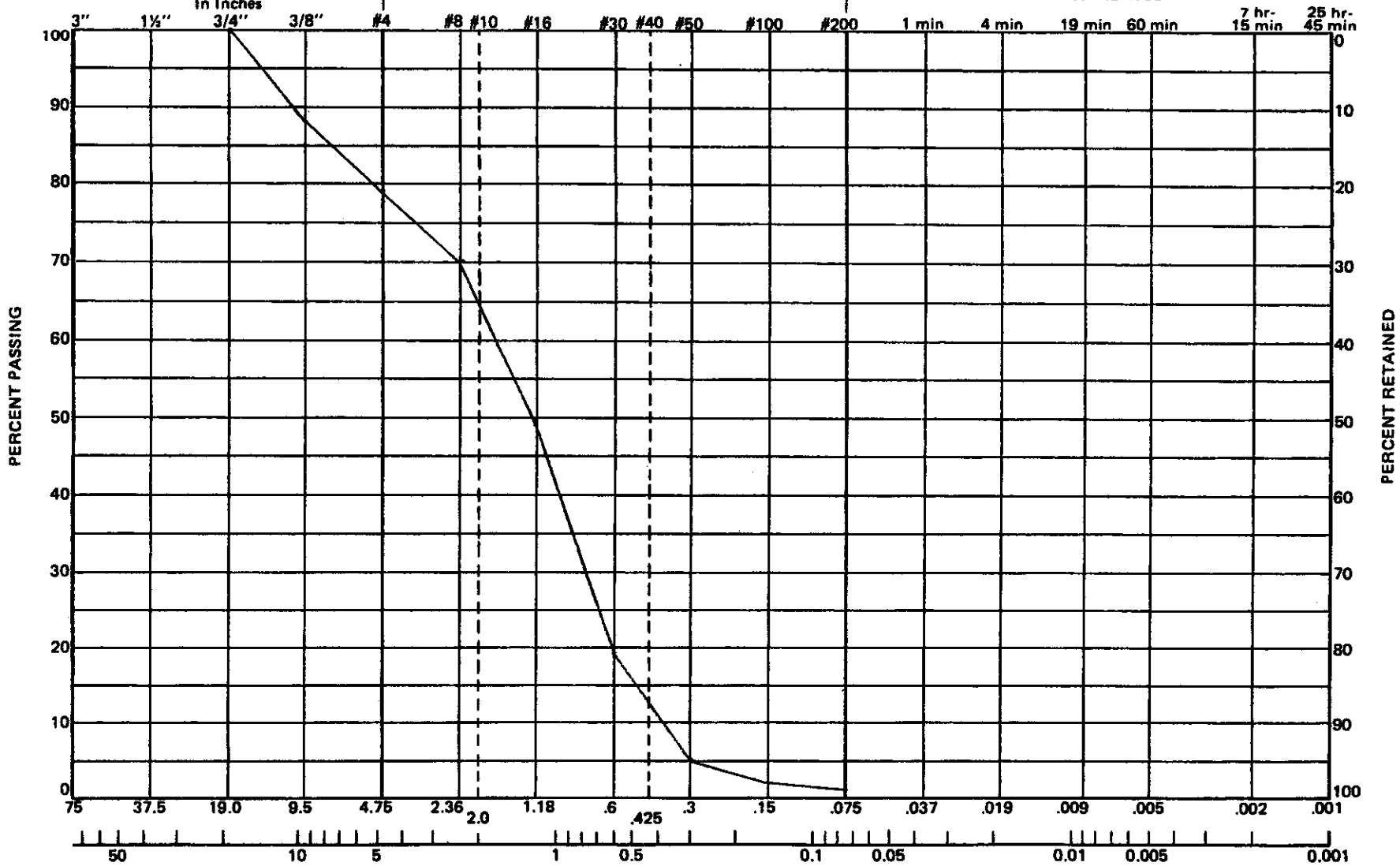
GPO 852-232

7-1415 (10-86)
Bureau of Reclamation

GRADATION TEST

Designation USBR _____ — —

PREPARED BY _____ CHECKED BY _____ FIGURE _____



SAMPLE NO.	HOLE NO.	ELEV. OR DEPTH ☒ft ☐m	UNIFIED SOIL CLASSIFICATION				ATTERBERG LIMITS			SPECIFIC GRAVITY		NOTES:
			GROUP SYMBOL	% GRAVEL	% SAND	% FINES	LL (%)	PI (%)	SL (%)	MINUS NO. 4	OTHER	
	AP-99-12	30.8-32.8	(SP)g	21	78	1				2.709		

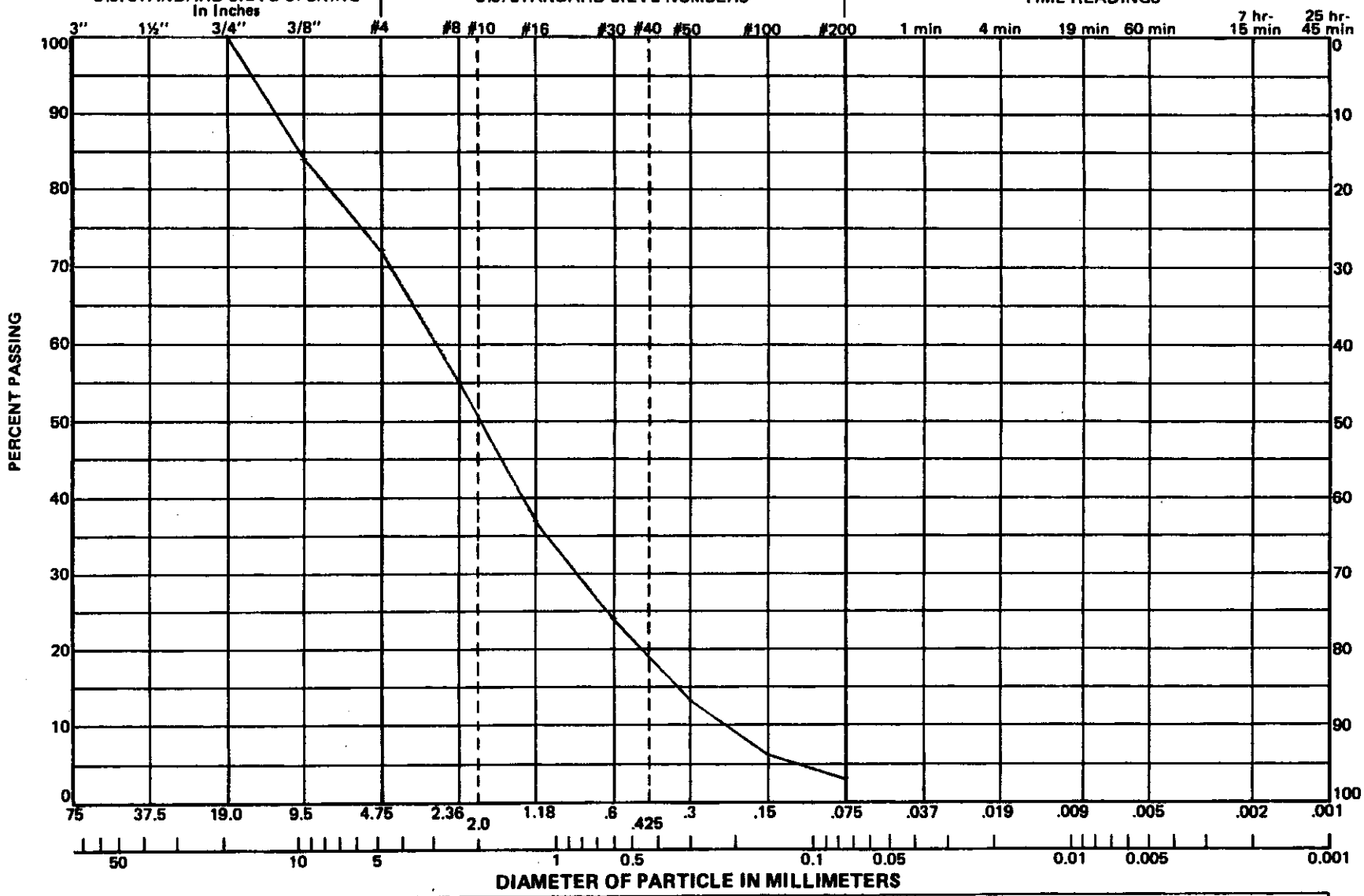
GPO 852-232

7-1415 (10-86)
Bureau of Reclamation

GRADATION TEST

Designation USBR _____ — — —

PREPARED BY _____ CHECKED BY _____ FIGURE _____



GRAVEL		SAND			FINES
COARSE	FINE	COARSE	MEDIUM	FINE	

SAMPLE NO.	HOLE NO.	ELEV. OR DEPTH ☒ft ☐m	UNIFIED SOIL CLASSIFICATION GROUP SYMBOL	% GRAVEL	% SAND	% FINES	ATTERBERG LIMITS LL (%)	PI (%)	SL (%)	SPECIFIC GRAVITY MINUS NO. 4	OTHER	NOTES:
	AP-99-12	35.7-37.7	(SW)g	28	69	3				2.727		

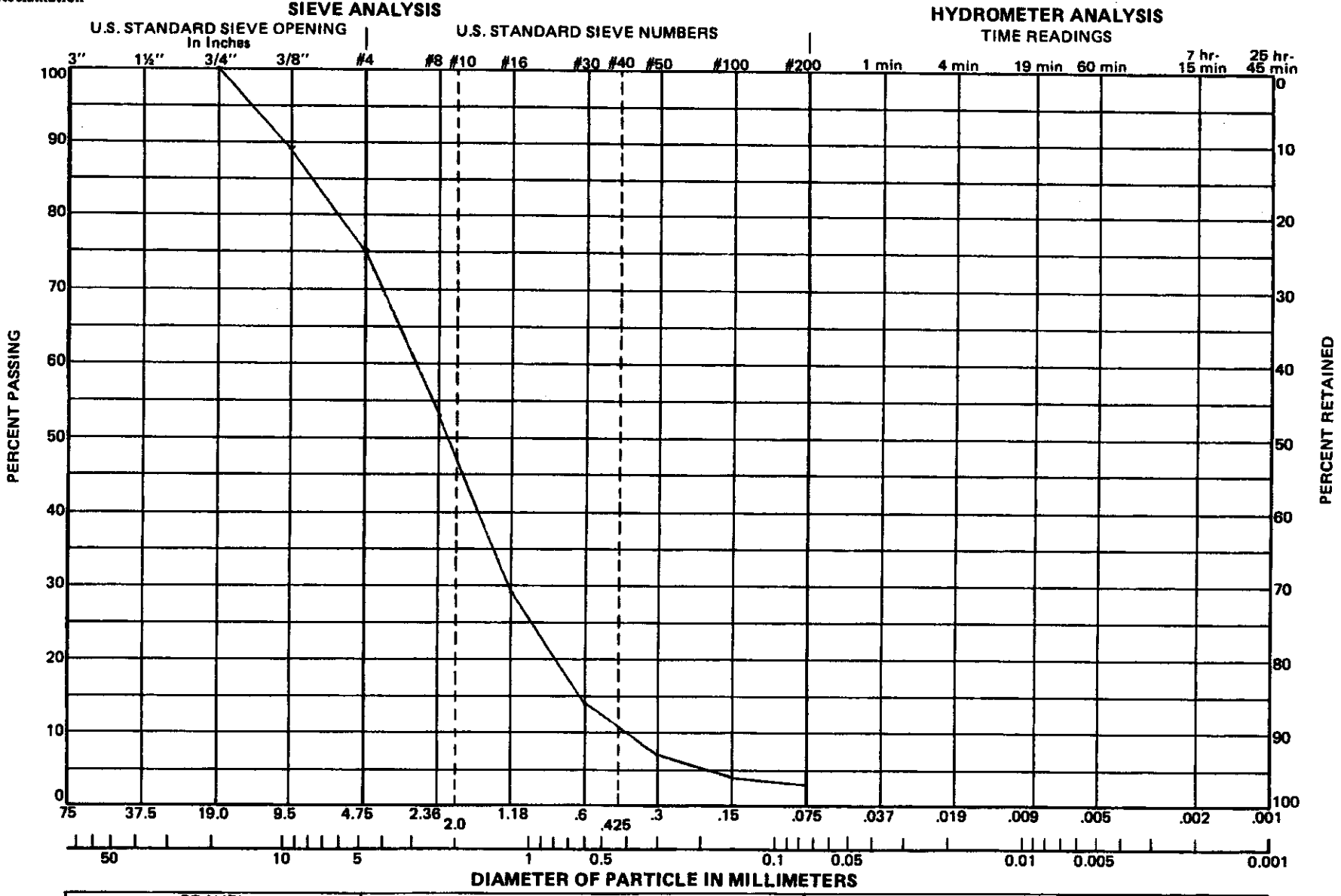
GPO 852-232

7-1415 (10-86)
Bureau of Reclamation

GRADATION TEST

Designation USBR _____

PREPARED BY _____ CHECKED BY _____ FIGURE _____



GRAVEL		SAND			FINES
COARSE	FINE	COARSE	MEDIUM	FINE	

SAMPLE NO.	HOLE NO.	ELEV. OR DEPTH ☒ft ☐m	UNIFIED SOIL CLASSIFICATION GROUP SYMBOL	% GRAVEL	% SAND	% FINES	ATTERBERG LIMITS LL (%)	PI (%)	SL (%)	SPECIFIC GRAVITY MINUS NO. 4	OTHER	NOTES:
	NP-99-12	41.1-43.1	(SW)g	25	72	3				2.749		

GPO 852-232

Attachment D

UNDERWATER MAPPING OF RESERVOIR CONDITIONS

United States Department of the Interior

BUREAU OF RECLAMATION
Pacific Northwest Region
1150 North Curtis Road, Suite 100
Boise, Idaho 83706-1234

IN REPLY
REFER TO:

PN-3600
PRJ-12.00

JAN 25 2000

MEMORANDUM

To: Area Manager, Lower Columbia Area Office, Portland OR
Attention: LCA-1000 (Glover)

From: Brent H. Carter, PN Regional Geologist/Underwater Inspection Team Leader (PN-3600)
Boise ID

Subject: Underwater Documentation of River Bottom Conditions Upstream of Savage Rapids Dam, September 24 through 25, 1999, Grants Pass Project, Oregon

General

The purpose of these underwater examinations was to observe and document river bottom conditions in the Rogue River upstream of Savage Rapids Dam to complement the ongoing sedimentation study. The PN Regional Drill Crew was concurrently performing explorations by drilling methods, from a barge, to sample representative bottom sediments accumulated overlying bedrock. This data will be utilized to estimate the volume of unconsolidated, potentially contaminated alluvial materials that will need to be evaluated for disposal under the removal schemes for Savage Rapids Dam.

Three diving traverses and three spot inspections were completed during the underwater work on September 24 and 25, 1999. PN Regional Underwater Inspection Team members participating in the examinations were Boise divers Mark Albl (PN-3233), Dennis Hawkins (PN-3425), and Brent Carter (PN-3600), Dive Master/Team Leader, and Grand Coulee diver Randy Harris (GCP-5600).

Water temperature was 57 degrees Fahrenheit. Underwater visibility was very good with recognition to four feet. The river elevation was about 964.0 feet (1929 NVGD datum) during the diving activities. The weather was mild, with air temperature 60 to 75 degrees Fahrenheit.

Background

No underwater examinations had been accomplished by U.S. Bureau of Reclamation divers in the Rogue River upstream of Savage Rapids prior to these investigations.

Examination Results

The locations of the underwater documentation traverses are referenced by river mile. Three traverses and three spot examinations were completed.

Traverse at River Mile 108.72

The underwater survey was accomplished from the south side of the river to the north side. At this location the river width was about 390 feet. Water depth varied from 8 to10 feet, with the bottom topography being fairly flat. Hard, subrounded gravels and cobbles to 10 inches in diameter, but mostly less than 5 inches, mantled the river bottom. Minor medium- to coarse-grained sand occurred in localized concentrations, of usually less than 15 feet in irregular configuration, to about 15 percent of the surface area within the gravel and cobbles.

Traverse at River Mile 109.00

At this location the Rogue River was about 230 feet in width. The underwater traverse was completed from the south shore to the north shore. Water depth varied from 10 to 26 feet. Along the south side of the river channel, bold outcrops of hard, *in situ* metavolcanics were exposed. The traverse started on the rock exposures that continued underwater for about 50 feet to the maximum depth of 26 feet. Beyond the 26-foot depth, the channel bottom was veneered with chiefly subrounded, gravel and cobbles to 12 inches in size, but were mostly 3 to 8 inches. Scattered, very small alluvial bars, less than 12 inches in thickness, of fine to medium sand were observed locally. The river bottom configuration to the north, from the maximum depth of 26 feet, gradually sloped upward to the depth of about 10 feet at the north shore.

Traverse at River Mile 109.63

This traverse was initiated on the north bank and progressed to the south shore. The river was about 310 feet wide at this location. Maximum water depth was 10 feet adjacent to the south bank of the river, but was generally 5 to 7 feet deep on the north side of the channel. Discontinuous exposures of *in situ* bedrock were observed along the south river bank and continued underwater. Most of the channel bottom was mantled with hard, subrounded cobbles to 10 inches in size, but were mostly 4 to 10 inches. Very little sand was noted.

Site Location at River Mile 107.60

This reconnoiter dive observed a previous drill location (drill hole AP-99-1) where a 30-foot string of auger flights had been lost off the barge. The site was in about 26 feet of water, with a bold exposure of *in situ* conglomerate immediately adjacent to the underwater drill location. The river bottom was covered with sandy gravel with the maximum size of about 2 inches. The gravel sizes were dominate with about 35 percent medium- to coarse-grained sand. Loose silt mantled the unconsolidated gravels from 1 to 2 inches in depth. Some organics were present in the overlying silts.

Site Location at River Mile 107.67

This site was the next location for the barge sample hole (marker buoy for drill hole AP-99-3). The water depth was 26 feet. The bottom was fairly smooth with a surficial layer of soft silt to depths of 2 to 9 inches. Organic debris in the silt was mostly 5 to 10 percent leaf, twig, and woody fragments. Fine- to medium-grained sand was underlying the silt. The loose sand was probed to depths of 18 inches with manual pressure.

Site Location at River Mile 107.69

This site location was made about midway between the marker buoys for AP-99-3 and AP-99-5. The water depth at this location was 20 feet. The river bottom was flat with 4 to 6 inches of soft silt veneering the surface. Some organic debris was present in the silt. Underlying the silt was compact gravelly sand with maximum size of 2 inches. Fine- to medium-grained sand predominated with about 30 percent subrounded gravel.

Conclusions

The three river traverses between River Mile 108.72 to 109.63 documented chiefly coarse-grained alluvium mantling the channel bottom of the Rogue River. These materials were mostly hard, subrounded gravels and cobbles with minor amounts of fine to coarse-grained sand. Exposures of bedrock were observed along the south side of the river channel at River Mile 109.00 and 109.63 traverses

Three site locations were examined adjacent to drill hole locations from River Mile 107.60 to 107.69 on the lower end of the reservoir near the dam. Where bottom conditions were observed, the reservoir sediments were veneered with shallow thicknesses of soft silt overlying generally loose, sand to gravelly sand to sandy gravel. The surficial river bottom silts often contained varying amounts of organic debris consisting of leaves, twigs, and tree fragments.

cc: Manager, Lower Columbia Area (Bend) Field Office, Bend OR
Attention: BFO-3200 (Magers)
PN-3000 (Beckmann), PN-3200 (Marriott), PN-3609 (Link)